School District of the City of St. Charles

7-12 Science

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7-12 Science
Curriculum Committee

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District Mission

The City of St. Charles School District will REACH, TEACH, and EMPOWER all students by providing a challenging, diverse, and innovative education.

District Vision

The City of St. Charles School District will be an educational leader recognized for high performance and academic excellence that prepares students to succeed in an ever-changing global society.

District Values

We, the City of St. Charles School District community of students, parents, staff, and patrons, value:

- ➢ High quality education for all students which includes:
  - Lifelong learning from early childhood through adult education
  - Rigorous learning experiences that challenge all students
  - Instruction that meets the needs of a diverse community
  - Respect for all
  - Real world, critical thinking and problem-solving skills to prepare students for the 21st Century
  - Developing caring, productive, and responsible citizens
  - Strong engagement of family and community
  - A safe, secure, and nurturing school environment
- ➢ Achievement through:
  - Celebration of individual success
  - Collaboration with parents and community stakeholders
  - Exploration, Innovation, and creativity
- ➢ High quality staff by:
  - Hiring and retaining highly qualified and invested employees
  - Providing professional development and collaboration focused on increasing student achievement
  - Empowering staff to use innovative resources and practices
- ➢ Informed decisions that are:
  - Student-centered
  - Focused on student achievement
  - Data Driven
  - Considerate of all points of view
  - Fiscally responsible

District Goals

For planning purposes, five overarching goals have been developed. These goals are statements of the key functions of the school district.

1. Student Performance
   - Develop and enhance the quality educational/instructional programs to improve student performance and enable students to meet their personal, academic, and career goals.
2. Highly qualified staff
   - Recruit, attract, develop, and retain highly qualified staff to carry out the District's mission, vision, goals, and objectives.
3. Facilities, Support, and Instructional Resource
   - Provide and maintain appropriate instructional resources, support services, and functional and safe facilities.
4. Parent and Community Involvement
   - Promote, facilitate and enhance parent, student, and community involvement in district educational programs.
5. Governance
   - Govern the district in an efficient and effective manner providing leadership and representation to benefit the students, staff, and patrons of the district.

School District Philosophical Foundations

Teachers in the School District of the City of St. Charles share in and ascribe to a philosophy that places children at the heart of the educational process. We feel that it is our professional responsibility to strive to be our best at all times and to maximize our efforts by ensuring that the following factors are present in our classrooms and our schools.

1. Learning is developed within the personal, physical, social, and intellectual contexts of the learner.
2. A strong educational program should provide developmental continuity.
3. The successful learner is motivated, strategic, knowledgeable, and interactive.
4. Children learn best when they have real purposes and can make connections to real life.
5. Effective learning is a combination of student exploration and teacher and mentor modeling.
6. Assessment is an ongoing and multidimensional process that is an integral part of instruction.
7. Making reading and writing connections across multiple sources and curricula facilitates meaning.
8. Literacy for the future means literacy in multiple technologies.
9. Education must respond to society's diverse population and serve all children.
10. Interactions among students, teachers, parents, and community form the network that supports learning.

Content Area Rationale

The 7-12 science curriculum ensures that the students within the City of St. Charles School District have the skills required to approach scientific phenomena with critical thinking. Based upon the Missouri Learning Standards (MLS) and Next Generation Science Standards (NGSS), the 7-12 science curriculum focuses on supporting students' methods of inquiry by learning through experiences and application of the scientific method. This curriculum, and the instructional methods employed by the teachers, is designed to encourage students to gain a deeper understanding of science and critical thinking methods.

Content Area Program Goals

- Asking Questions and Defining Problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in an argument from evidence
- Obtaining, evaluating, and communication information

Content Area Course Descriptions

PHYSICAL SCIENCE

(Science) 1 unit 9-12; prerequisite: None

Physical Science is an introductory science course designed to familiarize the student with concepts of matter, forces, and energy in the universe. Emphasis is on scientific literacy and hands-on investigation.

HONORS BIOLOGY 1

(Science) 1 unit 9-12; prerequisite: Signature of an instructor.

This course is designed to prepare talented students for eventual enrollment in Advanced Placement Science while learning about life processes expressed in both the unity and diversity of life. Emphasis in this course is based on cellular and molecular processes, the relationship between structure and function in living systems, and ecological interactions. Students will be required to take an "End of Course" exam provided by the State of Missouri at the completion of Biology 1.

BIOLOGY 1

(Science) 1 unit 10-12; prerequisite: None

Biology is the study of living systems and the interactions of organisms with their environment. This course consists of one semester of cellular biology with topics including body systems and cellular reproduction and one semester of ecology topics such as food webs and the interdependence of living organisms. Discussions, field work, research and laboratories will engage students in their learning. Students will be required to take an "End of Course" exam provided by the State of Missouri at the completion of Biology 1.

CHEMISTRY

(Science) 1 unit 11-12; prerequisite: Completion of Biology and Physical Science

Chemistry is the study of the composition, properties, and structure of substances. Topics include atomic theory, the periodic table, and chemical reactions. Emphasis is on problem solving and understanding the scientific method.

HONORS CHEMISTRY 1

(Science) 1 unit 10-11; prerequisite: Completion of Biology or Honors Biology, concurrent enrollment in Algebra 2 and signature of instructor is required for enrollment

Honors Chemistry is a challenging course covering traditional Chemistry topics. The intent of this course is to prepare talented students for eventual enrollment in Advanced Placement Science. It is designed for students who will be majoring in Science or Engineering in college.

PHYSICS

(Science) 1 unit 11-12; prerequisite: Concurrent enrollment in Chemistry or Honors Chemistry and concurrent enrollment in Algebra 2 or higher math course

Physics is the study of forces and energy. This course will focus on motion and the causes of motion. There is an emphasis on laboratory activities and problem solving.

HONORS PHYSICS 1

(Science) 1 unit 11-12 prerequisite: Chemistry or Honors Chemistry, concurrent enrollment in Pre-calculus and signature of instructor is required for enrollment

This course is designed to prepare students for AP Physics in their senior year. The first year will cover mechanics, which includes such topics as motion, forces, energy, and momentum. There is an emphasis on laboratory investigations and problem solving.

BIOLOGY 2—HUMAN BIOLOGY

(Science) 1 unit 11-12; prerequisite: Completion of Honors Biology or Biology and Chemistry or Honors Chemistry (Students can be concurrently enrolled in Chemistry with instructor approval)

This course will prepare students entering the medical career path. This course expands on the cellular level, expands on botany, as well as zoology. Human systems are studied extensively and are related to cat dissection. The curriculum will also cover forensics, ecology, anatomy and physiology as well as microbiology.

ENVIRONMENTAL SCIENCE

(Science) 1/2 unit 11-12; prerequisite:Completion of Biology or Honors Biology (Students can be concurrently enrolled in Chemistry with instructor approval)

Environmental Science is a one semester class. Students will learn about the interactions of humans, animals, and the environment. Topics will include Environmental chemistry and environmental biology.

FORENSIC SCIENCE

(Science) 1/2 unit 11-12; prerequisite: Completion of Biology or Honors Biology; concurrent enrollment in Chemistry

Forensic Science is a one semester class for students interested in careers in criminal justice. Topics include evidence collection, analysis, and evaluation.

APPLIED SCIENCE

(Science) 1 unit; 11-12; prerequisite: Students must complete Biology 1 and Physical Science; Signature of instructor is required for enrollment (Note: Course is not NCAA approved)

Applied Science students will study many of the same topics as General chemistry students with a reduction in the complexity of the mathematics involved. This course provides a survey of basic concepts and applications of chemistry with emphasis on the role of chemistry in the real world. Discussion of these basic chemistry concepts and their application to everyday life will be explored.

AP CHEMISTRY

(Science) 1 unit; 11-12; prerequisite: Algebra 2

AP CHEMISTRY LAB

(Science) 1/2 unit; 11-12 Prerequisite: AP Chemistry NOT to meet AP requirements students must enroll 2nd semester in AP Chemistry Lab

AP Chemistry is a one year course designed to prepare students for the AP Chemistry test. It is taught at the college level and is equivalent to the first two semesters of Chemistry for science majors Topics include reaction kinetics, thermochemistry, and chemical equilibrium.

AP PHYSICS

(Science) 1 unit; 12; prerequisite: Concurrent enrollment in Calculus

This course will prepare students for the AP Physics C exam. Students who pass the exam can earn college credit hours. Students will continue their studies of mechanics, including rotation, as well as adding a calculus component.

AP BIOLOGY

(Science) 1 unit 11-12; prerequisite: completion of Chemistry; concurrent enrollment in Chemistry

This course is equivalent to a college level introductory biology course. Students cultivate their understanding through inquiry-based investigations as they explore the following topics; Evolution, cellular processes -energy and communication, genetics, information, ecology and interactions.

(PLTW) PRINCIPLES OF BIOMEDICAL SCIENCES

(Science Elective) 1 unit; 9-12; prerequisite: None NOTE: This unit of credit does not count toward fulfilling the minimum credits required for graduation in science. It does, however, count toward an elective credit.

Students will explore concepts of biology and medicine to determine factors that led to the death of a fictional person. While investigating the case, students will examine autopsy reports, investigate medical history, and explore medical treatments that might have prolonged the person's life. The activities and projects introduce students to human physiology, basic biology, medicine, and research processes while allowing them to design their own experiments to solve problems. This is the introductory Project Lead the Way (PLTW) course in the Biomedical Science pathway.

(PLTW) HUMAN BODY SYSTEMS

(Science) 1 unit; 10-12; prerequisite: Principles of Biomedical Sciences.

Exploring science in action, students build organs and tissues on a skeletal manikin, work through interesting real world cases, and often play the role of biomedical professionals to solve medical mysteries. Students design experiments, investigate the structures and functions of the human body, and use data acquisition software to monitor body functions such as muscle movement, reflex and voluntary action, and respiration. Through projects such as determining the identity of a skeleton using both forensic anthropology and DNA analysis, students examine the interactions of human body systems and apply what they know to solve real-world medical cases.

(PLTW) MEDICAL INTERVENTIONS

(Science) 1 unit; 10-12; prerequisite: Human Body Systems

Students delve into activities like designing a prosthetic arm as they follow the life of a fictitious family and investigate how to prevent, diagnose, and treat disease. Students explore how to detect and fight infection; screen and evaluate the code in human DNA; evaluate cancer treatment options; and prevail when the organs of the body begin to fail. Through real-world cases, students are exposed to a range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics.

PLTW BIOMEDICAL INNOVATION

(1 credit; prerequisite: PLTW Medical Interventions)

In this course, students build on the knowledge and skills gained from previous courses to design their own innovative solutions for the most pressing health challenges of the 21st century. Students address topics ranging from public health and biomedical engineering to clinical medicine and physiology. They have the opportunity to work on an independent project with a mentor or advisor from a university, medical facility, or research institution.

Content Area Enduring Understandings/Essential Learning Outcomes

Seventh Grade Science

- Living things have basic needs for survival.
- Living things demonstrate certain characteristics that are not demonstrated in other nonliving objects
- Different types of cells have different structures
- Each structure has a specific function
- Cells are used to build tissues, organs, and organ systems
- Producers use photosynthesis to create glucose and oxygen.
- All eukaryotic organisms carry out cellular respiration to release stored energy from glucose.
- Osmosis and diffusion are needed to facilitate life processes.
- Organisms cells work together to maintain homeostasis.
- As multicellular organisms, plants consists of various interacting tissues, organs, and systems
- Plant systems rely on and respond to the environment
- Plants have various methods of reproduction
- The environment can impact plant growth
- The unique traits offered by plants make them a valuable resource for humans
- As multicellular organisms, animals consists of various interacting tissues, organs, and systems
- Animal systems rely on and respond to the environment
- Animals have various methods of reproduction
- The environment can impact animal population growth
- Viruses, bacteria, protists, and fungi can all cause disease that impact populations
- Viruses, bacteria, and fungi can be used to make medicine
- Bacteria, fungi, and algae have beneficial impacts on ecosystems
- Inheritance is the passing of genes from parents to offspring
- The structure of DNA influences many of the traits of organisms
- Asexual and sexual reproduction have different impacts on the inheritance of genes and traits of organisms
- Organisms inherit dominant and recessive genes.
- Overproduction, variation, and adaptation allow for natural selection to occur
- Natural selection is the mechanism that drives evolution
- Fossils, DNA, and common ancestors are evidence for evolution
- Humans influence inheritance through selective breeding and genetic modification
- Matter cycles through ecosystems

- Energy cycles through ecosystems
- Sunlight is the main source of energy for most of Earth's ecosystems
- Different organisms obtain energy in different manners
- Producers, consumers, and decomposers play key roles in earth's ecosystems
- Abiotic & biotic factors influence the population size of organisms within an ecosystem.
- Biomes consist of similar ecological levels.
- Living things interact with other organisms in their environment (symbiosis, competition, predator/prey)
- The health of an ecosystem can be measured by its biodiversity.
- Humans can positively or negatively influence earth's environment.

Eighth Grade Science

Earth's Place in the Universe

- Gravity impacts the motions of objects in the universe.
- The universe has observable properties and structures.
- Earth and its Solar System are part of the Milky Way Galaxy, which is one of many galaxies in the universe.
- Humans have been investigating space for centuries and technological advancements have helped us study space.
- Patterns of the apparent motion of the sun, the moon can be explained with models.
- Earth's axis is fixed in direction in space, but tilted relative to its orbit around the sun.
- The seasons are a result of Earth's tilt and are caused by the varying intensity of sunlight on different areas of Earth across the year.
- The structure of the solar system can explain eclipses of the sun and the moon.

Earth's Systems and Human Activity

- The transfer of energy results in the movement of water through Earth's systems
- Water changes form throughout the water cycle
- Earth's materials are limited
- Climate is influenced by many different factors
- The ocean exerts a major influence on climate
- Earth's climate has changed over time
- Complex patterns of air and water movement are major determinants of local weather patterns
- Weather can only be predicted probabilistically
- Technology helps us understand and predict natural hazards
- Earth's materials are recycled throughout earth systems
- Earth's energy and resources are distributed unevenly
- Water's movement changes surface features and underground formations
- Geoscience processes can change earth's surface at varying time scales
- Human population and consumption of natural resources impact earth systems
- Internal processes impact earth's surface
- Plate movement can cause events that impact the other earth systems
- Layers of rock provide a way to organize Earth's history.
- Studying rock layers and fossils help us have a relative understand of Earth's age

- Geoscience processes can change earth's surface at varying time scales
- Water's movement changes surface features and underground formations

Physical Science

- Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.
- Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
- Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understanding)
- The nature of science relies upon communication of results and justification of explanations.
- Students will understand motion relative to a frame of reference.
- Students will be able to represent the motion of an object by looking at a position/acceleration vs. time graph.
- Students will be able to determine net force acting on an object and whether or not the object is accelerating according to Newton's 1st Law.
- Forces are classified as either contact forces (pushes, pulls, friction, buoyancy) or non-contact forces (gravity, magnetism), that can be described in terms of direction and magnitude.
- Every object exerts a gravitational force on every other object
- Newton's Laws of Motion explain the interaction of mass and forces, and are used to predict changes in motion
- Perpendicular forces act independently of each other
- Momentum depends on the mass of the object and the velocity with which it is traveling
- Forms of energy have a source, a means of transfer (work and heat), and a receiver
- Mechanical energy comes from the motion (kinetic energy) and/or relative position (potential energy) of an object
- Energy can be transferred within a system as the total amount of energy remains constant (i.e., Law of Conservation of Energy)
- Work transfers energy into and out of a mechanical system
- The atomic model describes the electrically neutral atom
- Magnetic forces are related to electrical forces as different aspects of a single electromagnetic force
- Physical changes in states of matter due to thermal changes in materials can be explained by the Kinetic Theory of Matter
- Forms of energy have a source, a means of transfer (work and heat) and a receiver
- Forms of energy have a source, a means of transfer (work and heat) and a receiver
- Electromagnetic energy from the Sun (solar radiation) is a major source of Energy on Earth

- The Earth and multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range.
- Differentiation is the process of producing specialized cells within organisms, helping them to perform the essential functions of life.
- Biology and engineering combine in various ways to improve human life.
- The properties of organic and inorganic matter have the ability to control life's processes and can be recombined in different ways to form different products.
- All biomolecules are composed of the same elements that can be assembled and disassembled to carry out life processes.
- Photosynthetic organisms convert light energy to store chemical energy.
- All organisms use cellular respiration to convert stored chemical energy into usable energy.
- There is less usable energy as energy is transferred through trophic levels.
- Matter and energy begins with producers in an ecosystem and is transferred through consumers
- 1. Ecosystems have carrying capacities, which limits the numbers of organisms and populations they can support.
- 2. These limits result from such factors as availability of living and nonliving resources and from such challenges as predation, competition, and disease.
- 3. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem..

4. A complex set of intersections within an ecosystem within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

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1. An ecosystem can be studied by measuring size, changes, and relationships between its populations.
2. Populations remain stable or change based on various factors, biotic and abiotic, internal and external.

- Internal and external factors/signals influence a cell's ability to divide at different rates.
- Organisms use the process of mitosis for growth and repair.
- Differentiation produces different cell types using gene expression
- The structure of DNA allows storage of genetic information.
- Genetic instructions in DNA allow for the synthesis of specific proteins.
- Gene expression is regulated in a variety of ways at different points in the cell cycle
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- Organisms use the process of mitosis for growth and repair.
- Differentiation produces different cell types using gene expression
- The structure of DNA allows storage of genetic information.
- Genetic instructions in DNA allow for the synthesis of specific proteins.
- Gene expression is regulated in a variety of ways at different points in the cell cycle.
- Genetically varied gametes from each parent randomly combine during fertilization to provide unique traits in the offspring. (DNA in each parent's gamete combines during fertilization to determine offspring genetic makeup)
- Meiosis and sexual reproduction create new genetic combinations that contribute to genetic variation among generations.
- Random mutation can introduce new genes into an organism/species.
- An organism's genetics can be manipulated and combined with DNA from other organisms to create desired traits.
- Through the use of the fossil record, comparative anatomy, embryology, and DNA sequences, scientists have evidence to represent how life has changed over time.
- Organisms with traits that are more favorable to their environment, survive and reproduce at a greater rate than others.
- When enough anatomical, behavioral, or physiological variation develops between different groups in a species, then a new species may result.
- A species will go extinct if it can not evolve to survive in a changing environment.
- Evolution can follow different patterns such as convergent, divergent, and coevolution.
- Anthropogenic changes in the environment can disrupt an ecosystem and threaten the survival of some species.
- Human activity has the ability to find solutions in order to reverse negative impacts in an effort to increase biodiversity.
- Solutions need to take into account constraints like cost, safety, reliability and aesthetics while considering social, cultural, and environmental impacts.

Biology II/AP Biology

- Proper anatomical terminology is required for accurate and universal communication.
- Living things can be described, organized and classified based on levels of structural organization.
- Living things can be described, organized and classified based on levels of structural organization.
- Living things depend on maintaining homeostasis and necessary life functions.
- The cellular functions of the human body are based upon individual DNA sequences.
- Different types of stem cells provide various lines of cells that can contribute to advancements in medicine.
- Tissues of the human body are organized into epithelial, muscular, nervous, and connective depending on the overall structure and function it will provide.

- A collection of the same cell type will exist together in order to carry out a specific structure and function of an organ.
- The skeletal system is instrumental in the support, movement, and protection of the body.
- Bones are dynamic organs that interact and support other systems of the body.
- Bone identification and classification is based on size, function, composition, and location.
- Articulation identification and classification is based on function and structure.
- Certain types of bones are composed of specific and complex organization of bone tissue that aid in bone growth and maintenance.
- The muscular system plays a major role in movement, support, and homeostasis of the human body.
- Muscle types vary in structure to support their specific function.
- Muscles are named based on their location and action performed.
- Muscle tissue is composed of a complex and organized system of cells and protein fibers that allow for muscles to contract and relax.
- The nervous system senses information, processes that information, and responds using different neurons.
- The function of neurons is related to their specialized structure.
- The human body is composed of different nervous systems organized by various forms of stimuli.
- The sections of the brain and spinal cord are organized by white or gray matter and have specific functions or reflexes associated with each
- The heart pumps blood throughout the body which allows for the transfer of oxygen and nutrients to cells, and waste products away from cells.
- The anatomy of organs and structures of the cardiovascular system are directly related to their physiology.
- The respiratory system supplies oxygen to the blood while removing carbon dioxide.
- The anatomy of organs and structures of the respiratory system are directly related to their physiology
- The digestive system breaks down ingested food to particles small enough to be absorbed into the blood.
- The anatomy of organs and structures of the digestive system are directly related to their movement of digested food through the body.
- The urinary system rids the body of nitrogenous wastes while regulating water, electrolyte, and acid-base balance of the blood.
- The anatomy of organs and structures of the urinary system are directly related to their physiology.
- The endocrine system is a complex network of glands, tissues, and hormones that work in tandem with other body systems.
- Hormones are an integral part of maintaining homeostasis within the body.
- The cellular structures of the male and female reproductive systems provide a pathway for reproduction of the human body.

- Hormones for the male anatomy serve an important role in the production and protection of sperm.
- Female reproductive anatomy relies upon a complex cycle of hormones for the maturation of eggs and growth of a fetus.
- Pregnancy results in various changes of the female reproductive organs as well as the fetus.

Chemistry/Honors Chemistry/AP Chemistry

- Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select safe, appropriate investigative methods in order to obtain evidence relevant to the explanation.
- Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
- Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)
- Properties of a substance can change with alterations to its atomic/molecular structure
- Substances can be changed on a macroscopic level that will not alter its chemical properties
- Substances have properties that can be used to describe and classify them
- While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary
- Elements are made up of atoms that are composed of smaller particles.
- A Coulombic force exists between charged particles.
- Transmutations can occur by changing an atom's nucleus.
- There are multiple types of radioactive decay.
- The rate of decay for a nucleus is represented by its half-life.
- The organization of the periodic table is based on the properties of the elements
- Patterns in the periodic table can be found to describe the relative size of an atom or ion as well as the reactivity of an atom or ion
- The type of bonding affects the properties of a compound.
- The type of bond determines its nomenclature.
- Balanced chemical equations are used to derive relationships between reactants and products in a chemical change
- The type of bond determines its nomenclature.
- Molecular formulas show the number of each type of atom in a molecule
- Molecules have particular shapes depending on number of atoms and electron domains
- Balanced chemical equations are used to derive relationships between reactants and products in a chemical change
- The mole is used to represent a large collection of particles.

- Quantities of a substance can be expressed in terms of moles, mass, volume, and number of particles.
- Mass and atoms must be conserved in a chemical reaction.
- A balanced chemical equation is necessary to relate quantities of reactants and products.
- Reactants and products in a chemical reaction are quantitatively related by the mole.
- The amount of product recovered is determined by the limiting reactant.
- Numerous factors influence the percent yield of a chemical reaction
- Kinetic molecular theory can be used to explain the difference in properties of solids, liquids and gasses.
- Gas behavior can be quantitatively described using pressure, temperature, volume and mole relationships
- Solutions can be described in both qualitative and quantitative terms.
- Solutions can be classified as acidic or basic based upon the concentration of hydrogen and hydroxide ions present.

Physics/Honors Physics/AP Physics

- Scientists use experiments to investigate the universe. They use the data collected to create mathematical models to explain and predict what they see. Scientists must be able to explain their work and defend it if it is going to be accepted as "true."
- Motion can only be defined relative to an arbitrary frame of reference.
- A vector is a quantity that incorporates direction.
- Graphs and equations can be used to model and predict motion.
- The vertical and horizontal components of the motion of a projectile are independent of each other. Because of this, one dimensional models can be used to analyze two dimensional projectile motion.
- Bodies in free fall have the same acceleration regardless of mass.
- A force is an interaction between two objects that affects both objects equally. (Newton's 3rd)
- A force is needed to change the motion of an object, not to cause motion. (Newton's 1st)
- Acceleration occurs only when a net force acts on a system. The acceleration is proportional to the force and inversely proportional to the mass of the system. (Newton's 2nd)
- Energy can be stored in various ways and can be transferred from system to system, but the total amount always remains the same.
- Work is the transfer of energy from system to system via a force.

Forensic Science

- Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations
- Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)

- The nature of science relies upon communication of results and justification of explanations
- Forensic Science is an applied science which pulls from other scientific fields
- Forensic Science has a lengthy history that continues to evolve with technological advances
- The primary goal of Forensics is to recreate the crime scene
- Collecting and packaging evidence according to protocol is a critical process to solving crimes
- Searching and collecting evidence must be systematic in nature.
- Evidence can be classified based on its characteristics or type
- During decomposition certain bodily process occur that can be used to deduce time and cause of death
- Certain evidences have a higher probative value in that they can be individualized
- That fingerprints can be classified into three different patterns; arch, loops and whorls
- Fingerprints remain unchanged throughout an individual's lifetime.
- Fingerprints have ridge characteristics called minutiae that make a fingerprint unique
- Fingerprints often require a treatment to make them visible. The treatment used is dependent on the surface.
- Fingerprints are individually unique, and thus have high probative value
- Blood is made up of antibodies and antigens that allow us to classify blood type.
- Blood evidence is circumstantial evidence.
- Shape of blood droplets can be dependent on height, surface and angle of impact
- Using trigonometry, a point of origin can be determined.
- The physics of blood spatter is often a more accurate method of determining what happened at a crime scene than testimony.
- Animal and human hair have similarities in their morphology but have variations in that structure that allow for investigators to distinguish them as human hair.
- Hair progresses through three different stages that change root shape which changes how much DNA can be extracted.
- Hair is generally considered class evidence unless it contains follicular tissue.
- Fibers have properties that can be determined using chemical testing

Environmental Science

- Life processes can be disrupted by disease (intrinsic failures of the organ systems or by infection due to other organisms).
- The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.
- That there is an importance in the diversity of a forest and trees in an urban setting.
- Trees play an essential role in an ecosystem, providing habitat stability, photosynthetic processes, and influence the cycling of materials in the environment.
- All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem
- Fresh water is limited and must be protected and conserved to ensure availability to

humans.
- Flood plains have an important ecological function in protecting waterways.
- Earth's materials are limited natural resources affected by human activity
- Organisms progress through their own unique life cycle
- Biological classifications are based on relation of organisms to each other
- Every species of organism has inheritable variation
- Balanced ecosystems rely on interaction between all organisms and the resources available in the ecosystem
- Living organisms will reach a carrying capacity due to the limited resources that are available
- All activities (including human) cause change in ecosystems
- Species diversity is influenced by external factors as well
- All organisms, including human activity cause changes in the environment which affects the ecosystem
- Earth's materials are limited natural resources affected by human activity
- Climate is a description of the average weather conditions in a given area due to the transfer of energy and matter through the system (Earth)
- Advances in technology often result in improved data collection an increased scientific understanding
- Scientific theories are developed based on current information and must be rigorously tested for validity
- The progress of science and technology greatly affects the current social, political, economic, ethical, and environmental ideals of a society

STANDARDS BY GRADE/COURSE	*KEY: (I) INTRODUCE (R)REMEDIATE (E) EXPAND*
7th Grade Life Science	
6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.	**R/I**
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.	**R/I**
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.	**R/I**
6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.	**R/I**
6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.	**R/I**
6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.	**R/I**
6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations.	**R/I**
6-8.LS4.B.1 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.	**R/I**
6-8.LS4.B.2 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.	**R/I**
8th Grade Earth Science	
6-8.ESS1.A.3 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.	**R/1**
6-8.ESS1.A.1: Develop and use a model of the Earth-sun-moon to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons	**R/I**
6-8.ESS2.C.1 Design and develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.	**R/I**
6-8.ESS2.C.3 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation t	**R/I**
6-8.ESS2.C.2 Research, collect, and analyze data to provide evidence for how the motions and complex interactions of air masses result in changes in we	**R/I**
6-8.ESS2.B.1 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the pas	**R/I**
6-8.ESS2.A.1 Develop and use a model to illustrate that energy from the Earth’s interior drives convection which cycles Earth’s crust leading to melting, cr	**R/I**
6-8.ESS1.C.1 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth’s 4.6-billion-y	**R/I**
Physical Science	
Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] (9-12.PS2.A.1)	**R/I**
Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] (9-12.PS3.A.1)	**R/I**
Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (9-12.PS2.B.2)	**R/I**
Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). (9-12.PS1.A.3)	**R/I**

STANDARDS BY GRADE/COURSE	***KEY: (I) INTRODUCE (R)REMEDIATE (E) EXPAND***
Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] (9-12.PS3.B.1)	**R/I**
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media (9-12.PS4.A.1).	**R/I**
Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] (9-12.PS4.A.2)	**R/I**
Biology	
9-12 LS1-A-3- Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.(NGSS: HS-LS1-3)	**R/I**
9-12 LS1-C-1- Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. (NGSS: HS-LS1-5)	**R//E**
9-12 LS2-B-1- Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow. (NGSS: HS-LS2-3)	**R/I**
9-12 LS3-B-2-Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure (NGSS: MS-LS3-2.)	**R/I**
9-12 LS4-C-2-Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.(NGSS: HS-LS4-5)	**R/I**
Chemistry	
9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]	**R/I**
9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]	**R/I**
9-12.PS1.A.2 Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, or of oxygen and hydrogen.]	**R/I**
9-12.PS1.A.3 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]	**R/I**
9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on conservation of matter and mass through balanced chemical equations, use of the mole concept and proportional relationships.]	**R/I**

STANDARDS BY GRADE/COURSE	***KEY: (I) INTRODUCE (R)REMEDIATE (E) EXPAND***
9-12.PS1.A.4 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).	**R/I**

[Seventh Grade Life Science] *Course Overview*	
Grade level(s): 7th	
Course Rationale	**Course Description**
Seventh grade life science lays the groundwork for high school biology.	*Life science is the study of how living things grow, develop, and interact with their environment.*
Transfer Goals/Big Ideas	
Transfer Goals: ● *Asking questions and defining problems* ● *Developing and using problems* ● *Planning and carrying out investigations* ● *Analyzing and interpreting data* ● *Using mathematics and computational thinking* ● *Constructing explanations and designing solutions* ● *Engaging in argument from evidence* ● *Obtaining, evaluating and communicating information* *Big Ideas:* ● *The structure of organisms controls their growth and development* ● *Biotic and abiotic factors interact in ecosystems* ● *Genetics of populations affects their survival and progression over time*	

Priority Missouri Learning Standards/National Standards
6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.
6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations.
6-8.LS4.B.1 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
6-8.LS4.B.2 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

<table>
<tr><th colspan="3"> 
Unit 1: Traits of Life
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.</td><td colspan="2">Transfer Goals:
● Engaging in argument from evidence
● Planning and carrying out investigations
Big Ideas:
● The structure of organisms controls their growth and development
● Biotic and abiotic factors interact in ecosystems</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Living things have basic needs for survival.
● Living things demonstrate certain characteristics that are not demonstrated in other nonliving objects.</td><td>1. What are the basic needs of life?
2. How are living things different from nonliving things?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
● Students will identify the basic needs of life.
● Students will describe the traits of life.
● Students will use their knowledge of needs and traits of life to draw conclusions and formulate arguments whether an object is living or nonliving.</td></tr>
<tr><th colspan="3">Unit Duration:</th></tr>
<tr><td colspan="3">This unit will last for 10 - 15 days.</td></tr>
</table>

<table>
<tr><th colspan="3"> 
Unit 2: Cell Types, Structure, and Function
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.</td><td colspan="2">Transfer Goals:
● Constructing explanations
● Carrying out investigations
Big Ideas:
● The structure of organisms controls their growth and development</td></tr>
<tr><td>Enduring Understandings
● Different types of cells have different structures
● Each structure has a specific function
● Cells are used to build tissues, organs, and organ systems</td><td>Essential Questions
1. How are plant and animal cells alike and different?
2. Why do organisms need the cell membrane, chloroplast, mitochondria, nucleus, and cell wall in their cells?
3. How are prokaryotic and eukaryotic cells alike and different?
4. How do components of an organism build upon each other?</td></tr>
</table>

Learning Targets
Students will… ● *Compare and contrast plant, animal, and prokaryotic cells.* ● *Identify the fab five cell organelles.* ● *Describe the functions of the fab five cell organelles.* ● *Identify the levels of organization that make up a multicellular organism.*
Unit Duration
This unit will last for 10 - 15 days.

Unit 3: Cell Processes
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">PRIORITY
6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.

SUPPLEMENTAL
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.</td><td colspan="2">Transfer Goals:
● Engaging in argument from evidence
● Planning and carrying out investigations
● Using mathematics and computational thinking
Big Ideas
● The structure of organisms controls their growth and development
● Biotic and abiotic factors interact in ecosystems</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Producers use photosynthesis to create glucose and oxygen.
● All eukaryotic organisms carry out cellular respiration to release stored energy from glucose.
● Osmosis and diffusion are needed to facilitate life processes.
● Organisms cells work together to maintain homeostasis.</td><td>1. How do living organisms exchange materials with the environment to survive?
2. How do living organisms exchange materials within themselves to survive?</td></tr>
</table>

Learning Targets
Students will… ● ***Describe how molecules move to reach equilibrium.*** ● ***Identify the reactants and products of photosynthesis and cellular respiration.*** ● ***Describe how the reactants are obtained in photosynthesis and cellular respiration.*** ● ***Describe how diffusion and osmosis help an organism maintain homeostasis.***
Unit Duration:
This unit will last for 10 - 15 days.

<table>
<tr><td colspan="3"> 
Unit 4: Plant Systems and Reproduction
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="2">PRIORITY
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

SUPPLEMENTAL
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.</td><td colspan="2">Transfer Goals:
● Asking questions and defining problems
● Developing and using problems
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
Big Ideas
● The structure of organisms controls their growth and development
● Biotic and abiotic factors interact in ecosystems
● Genetics of populations affects their survival and progression over time</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● As multicellular organisms, plants consists of various interacting tissues, organs, and systems
● Plant systems rely on and respond to the environment
● Plants have various methods of reproduction</td><td>1. How do the various tissues, organs, and systems that make up plants interact?
2. How do biotic and abiotic factors affect the growth and development of plants?
3. Describe the methods of plant reproduction.
4. How are plants used to benefit humans?</td></tr>
</table>

	● *The environment can impact plant growth* ● *The unique traits offered by plants make them a valuable resource for humans*	

Students will…

- ***Investigate the interactions between the tissues, organs, and systems within plants.***
- ***Analyze the effects of biotic and abiotic factors on the growth and development of plants.***
- ***Describe the methods of plant reproduction.***
- ***Investigate plants as a natural resource.***

Unit Duration:

This unit will last for 10 - 15 days.

<table>
<tr><th colspan="3">Unit 5: Animal Systems and Reproduction
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">PRIORITY
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

SUPPLEMENTAL
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.</td><td colspan="2">Transfer Goals:
● Asking questions and defining problems
● Developing and using problems
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
Big Ideas
● The structure of organisms controls their growth and development
● Biotic and abiotic factors interact in ecosystems
● Genetics of populations affects their survival and progression over time</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● As multicellular organisms, animals consists of various interacting tissues, organs, and systems
● Animal systems rely on and respond to the environment
● Animals have various methods of reproduction
● The environment can impact animal population growth</td><td>1. How do the various tissues, organs, and systems that make up animals interact to maintain homeostasis?
2. How do biotic and abiotic factors affect the growth and development of animals?
3. Describe the methods of animal reproduction.
4. Identify internal and external factors and how they affect animals.</td></tr>
</table>

Learning Targets
Students will… ● ***Investigate the interactions between the tissues, organs, and systems within animals.*** ● ***Analyze the effects of biotic and abiotic factors on the growth and development of animals*** ● ***Describe the methods of animal reproduction***
Unit Duration:
This unit will last for 10 - 15 days.

<table>
<tr><th colspan="3"> 
Unit 6: Viruses & Microorganisms</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">PRIORITY
6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.

SUPPLEMENTAL
6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations.</td><td colspan="2">Transfer Goals:
● Asking questions and defining problems
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations
● Obtaining, evaluating and communicating information
Big Ideas:
● Biotic and abiotic factors interact in ecosystems</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Viruses, bacteria, protists, and fungi can all cause disease that impact populations
● Viruses, bacteria, and fungi can be used to make medicine
● Bacteria, fungi, and algae have beneficial impacts on ecosystems</td><td>1. How are diseases caused by viruses, bacteria, protists, and fungi?
2. How are viruses, bacteria, and fungi used to make various medicines?
3. In what ways are bacteria, fungi, and protists beneficial?</td></tr>
</table>

Learning Targets
Students will… ● *Match diseases to the viruses or microorganisms that cause them* ● *Recognize medicines that are produced by viruses, bacteria, and/or fungi* ● *Describe ways in which bacteria, fungi, and protists are beneficial to ecosystems*
Unit Duration:
This unit will last for 10 - 15 days.

Unit 7: Reproduction & Heredity
Desired Results

Standards	Transfer Goal(s) /Big Ideas
PRIORITY **6-8.LS4.B.1 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.** **SUPPLEMENTAL** **6-8.LS4.B.2 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.**	*Transfer Goals:* ● *Asking questions and defining problems* ● *Developing and using problems* ● *Planning and carrying out investigations* ● *Analyzing and interpreting data* ● *Constructing explanations* ● *Engaging in argument from evidence* ● *Obtaining, evaluating and communicating information* *Big Ideas* ● *The structure of organisms controls their growth and development* ● *Genetics of populations affects their survival and progression over time*

Enduring Understandings	Essential Questions
● *Inheritance is the passing of genes from parents to offspring* ● *The structure of DNA influences many of the traits of organisms* ● *Asexual and sexual reproduction have different impacts on the inheritance of genes and traits of organisms*	1. *Why do organisms share traits with their ancestors, parents, and offspring?* 2. *How does the structure of DNA influence traits of organisms?* 3. *What are the different impacts of asexual and sexual reproduction on the inheritance of genes and traits of organisms?*

	● *Organisms inherit dominant and recessive genes.*	4. *Explain how dominant and recessive genes can be expressed in offspring.*
Learning Targets		
Students will… ● ***Identify and describe the structures of the cell that influence inheritance.*** ● ***Use models to predict the probability of traits in offspring.*** ● ***Identify and describe methods of asexual reproduction.*** ● ***Construct an explanation of trait inheritance. (Dominant and recessive traits)***		
Unit Duration:		
This unit will last for 10 - 15 days.		

<table>
<tr><td colspan="3"> 
Unit 8: Natural Selection
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">PRIORITY
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

SUPPLEMENTAL
6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.</td><td colspan="2">Transfer Goals:
● Asking questions and defining problems
● Planning and carrying out investigations
● Constructing explanations
● Engaging in argument from evidence
● Obtaining, evaluating, and communicating information
Big Ideas
● The structure of organisms controls their growth and development
● Genetics of populations affects their survival and progression over time</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Overproduction, variation, and adaptation allow for natural selection to occur
● Natural selection is the mechanism that drives evolution
● Fossils, DNA, and common ancestors are evidence for evolution
● Humans influence inheritance through selective breeding and genetic modification</td><td>1. How does natural selection occur?
2. What is the relationship between natural selection and evolution?
3. What evidence is there for evolution?
4. How do humans alter the genetic information of selected organisms?</td></tr>
</table>

Course Name: Life Science grade 7

Learning Targets
Students will… ● ***Describe the process of natural selection.*** ● ***Identify natural selection as the driving force of evolution.*** ● ***Interpret evidence for evolution.*** ● ***Identify ways humans can alter the genetic information of organisms for desired results.***
Unit Duration:
This unit will last for 10 - 15 days.

Unit 9: Matter and Energy in Ecosystems
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">PRIORITY
6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.</td><td colspan="2">Transfer Goals:
Asking questions and defining problems
Developing and using problems
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations
Obtaining, evaluating and communicating information
Big Ideas
Biotic and abiotic factors interact in ecosystems</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>Matter cycles through ecosystems
Energy cycles through ecosystems
Sunlight is the main source of energy for most of Earth’s ecosystems
Different organisms obtain energy in different manners
Producers, consumers, and decomposers play key roles in earth’s ecosystems</td><td>What are ways in which different types of matter are used throughout the ecosystem?
How does energy change as it cycles through the ecosystem?
How do organisms obtain energy?
How do producers, consumers, and decomposers play a key role in earth's ecosystems?</td></tr>
</table>

Course Name: Life Science grade 7

Learning Targets
Students will… ● ***Describe ways in which matter cycles through ecosystems.*** ● ***Construct maps and diagrams that show the flow of energy through ecosystems.*** ● ***Identify the sun as the main source of energy for earth's organisms.*** ● ***Identify how producers, consumers, and decomposers obtain energy.*** ● ***Explain the roles that producers, consumers, and decomposers play in their ecosystems.***
Unit Duration:
This unit will last for 10 - 15 days.

Unit 10: Ecosystem Relationships & Dynamics

Desired Results

Standards	Transfer Goal(s) /Big Ideas	
PRIORITY **6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.** **SUPPLEMENTAL** **6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations.**	*Transfer Goals:* ● *Asking questions and defining problems* ● *Developing and using problems* ● *Planning and carrying out investigations* ● *Analyzing and interpreting data* ● *Using mathematics and computational thinking* ● *Constructing explanations* ● *Obtaining, evaluating and communicating information* *Big Ideas* ● *Biotic and abiotic factors interact in ecosystems*	
	Enduring Understandings	**Essential Questions**
	● *Abiotic & biotic factors influence the population size of organisms within an ecosystem.* ● *Biomes consist of similar ecological levels.* ● *Living things interact with other organisms in their environment (symbiosis, competition, predator/prey)* ● *The health of an ecosystem can be measured by its biodiversity.* ● *Humans can positively or negatively influence earth's environment.*	1. *How do abiotic and biotic factors influence the population size of organisms within an ecosystem?* 2. *How do components of the environment build upon each other to create levels within a biome?* 3. *In what ways do living things interact with each other in their environment?* 4. *How can humans positively or negatively influence earth's environment?*

Course Name: Life Science grade 7

Learning Targets
Students will… ● ***Analyze how abiotic and biotic factors influence the population size of organisms within an ecosystem*** ● ***Compare and contrast the ecological levels within an ecosystem*** ● ***Classify examples of symbiotic relationships*** ● ***List and analyze ways that living things interact with each other in their environment*** ● ***Develop solutions to reverse the negative impacts of human activities on the environment***
Unit Duration:
This unit will last for 10 - 15 days.

Strand: 6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.			
Topic: Traits of Life			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** Defend why characteristics and needs of life are necessary for survival of a living organism.		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ●
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Students will use their knowledge of needs and traits of life to draw conclusions and formulate arguments whether an object is living or nonliving.***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***use their knowledge of needs and traits of life to draw conclusions and formulate arguments whether an object is living or nonliving.***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: 6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.			
Topic: Cell Structure and Functions			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** Investigate the functions of various cell structures and how they interact.		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ●
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● **Compare and contrast the structures and functions of plant, animal, and bacteria cells.** ● **Describe the levels of organization (cells, tissues, organs, organ systems) that make up a multicellular organism.**		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● **Compare and contrast the structures and functions of plant, animal, and bacteria cells.** ● **Describe the levels of organization (cells, tissues, organs, organ systems) that make up a multicellular organism.**		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: **PRIORITY** **6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.** **SUPPLEMENTAL** **6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.** **6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.**			
Topic: Cell Processes			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** Investigate the relationship between the processes of photosynthesis and cellular respiration.		**Sample Task** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: **Describe what would happen if all photosynthetic organisms disappeared from planet earth.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● **Describe the process that plants use to produce energy.** ● **Describe how oxygen and mitochondria are important for the survival of** ● **most organisms.** ● **Describe the role of chloroplast and chlorophyll in photosynthesis** ● **Explain the relationship between photosynthesis and cellular respiration** ● **Describe how materials are transported in and out of the cell.**		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●

	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● **Describe the process that plants use to produce energy.** ● **Describe how oxygen and mitochondria are important for the survival of** ● **most organisms.** ● **Describe the role of chloroplast and chlorophyll in photosynthesis** ● **Explain the relationship between photosynthesis and cellular respiration** ● **Describe how materials are transported in and out of the cell.**		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand:
PRIORITY
6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

SUPPLEMENTAL
6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.			
Topic: Plant Systems and Reproduction			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Design a plant with appropriate structures to carry out life processes in a particular environment. ● Discuss the implications of genetic engineering on plants. How could it affect their growth, development, functions, and reproduction?		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ● **Design a plant to survive in a particular set of environmental conditions**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Determine the interactions between the tissues, organs, and systems within plants.*** ● ***Analyze the effects of biotic and abiotic factors on the growth and development of plants.*** ● ***Describe the methods of plant reproduction.*** ● ***Explain how plants can be used as a natural resource.***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***Determine the interactions between the tissues, organs, and systems within plants.*** ● ***Analyze the effects of biotic and abiotic factors on the growth and development of plants.*** ● ***Describe the methods of plant reproduction.*** ● ***Explain how plants can be used as a natural resource.***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	

Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY

6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

SUPPLEMENTAL

6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Topic: Animal Systems and Reproduction

Grade: 7

Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Construct an argument about which body system is the most important for the survival of an organism (given a specific animal)		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ●
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● **Identify specific traits that are used to classify animals** ● **Explain various methods that animals use for successful reproduction** ● **Describe the interactions between body systems to maintain homeostasis**		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● **Identify specific traits that are used to classify animals** ● **Explain various methods that animals use for successful reproduction** ● **Describe the interactions between body systems to maintain homeostasis**		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY **6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.** **SUPPLEMENTAL** **6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations.**			
Topic: Viruses and Microorganisms			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Defend how viruses can be beneficial using evidence from research-based articles		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ●
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● *Match diseases to the viruses or microorganisms that cause them* ● *Recognize medicines that are produced by viruses, bacteria, and/or fungi* ● *Describe ways in which bacteria, fungi, and protists are beneficial to ecosystems*		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● *Match diseases to the viruses or microorganisms that cause them* ● *Recognize medicines that are produced by viruses, bacteria, and/or fungi* ● *Describe ways in which bacteria, fungi, and protists are beneficial to ecosystems*		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY
6-8.LS4.B.1 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

SUPPLEMENTAL
6-8.LS4.B.2 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Topic: Reproduction and Heredity

Grade: 7

Score	4.0. Knowledge and inferences or applications beyond what was taught.	Sample Tasks
4.0	Predict how genetic modification could affect the evolution of a population or species	*4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ●

	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Identify and describe the structures of the cell that influence inheritance.*** ● ***Use models to predict the probability of traits in offspring.*** ● ***Identify and describe methods of asexual reproduction.*** ● ***Construct an explanation of trait inheritance. (Dominant and recessive traits)***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***Identify and describe the structures of the cell that influence inheritance.*** ● ***Use models to predict the probability of traits in offspring.*** ● ***Identify and describe methods of asexual reproduction.*** ● ***Construct an explanation of trait inheritance. (Dominant and recessive traits)***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY **6-8.LS1.B.1 An explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively.** **SUPPLEMENTAL** **6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.**		
Topic: Natural Selection		
Grade: 7		
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Design an organism with adaptations to survive a given environment that will undergo changes over time.	**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*:

			● Design a plant or animal with adaptations to survive a given alien environment that will undergo changes over time.
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Describe the process of natural selection.*** ● ***Identify natural selection as the driving force of evolution.*** ● ***Understand evidence for evolution.*** ● ***Identify ways humans can alter the genetic information of organisms for desired results.***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***Describe the process of natural selection.*** ● ***Identify natural selection as the driving force of evolution.*** ● ***Understand evidence for evolution.*** ● ***Identify ways humans can alter the genetic information of organisms for desired results.***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY 6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.		
Topic: Matter and Energy in Ecosystems		
Grade: 7		
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Describe the extended impacts on populations in a food web if one of the populations increases or decreases based on feeding relationships.	**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*:

	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Describe ways in which matter cycles through ecosystems.*** ● ***Construct maps and diagrams that show the flow of energy through ecosystems.*** ● ***Identify the sun as the main source of energy for earth's organisms.*** ● ***Identify how producers, consumers, and decomposers obtain energy.*** ● ***Explain the roles that producers, consumers, and decomposers play in their ecosystems.***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***Describe ways in which matter cycles through ecosystems.*** ● ***Construct maps and diagrams that show the flow of energy through ecosystems.*** ● ***Identify the sun as the main source of energy for earth's organisms.*** ● ***Identify how producers, consumers, and decomposers obtain energy.*** ● ***Explain the roles that producers, consumers, and decomposers play in their ecosystems.***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●
	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

PRIORITY
6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem.

SUPPLEMENTAL
6-8.LS2.C.1 Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an

ecosystem affect populations.			
Topic: Relationships and Dynamics in Ecosystems			
Grade: 7			
Score 4.0	**4.0. Knowledge and inferences or applications beyond what was taught.** ● Design a model or graph to show the impact of a limiting factor on multiple populations within an ecosystem. ● Develop an initiative to address a waste or energy problem.		**Sample Tasks** *4.0 ASSESSMENT ITEMS: As a result of understanding or being skilled at the knowledge identified in 3.0 the student is able to*: ● Develop a school-wide initiative to address a waste or energy problem within the building.
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes* ● ***Analyze how abiotic and biotic factors influence the population size of organisms within an ecosystem*** ● ***Compare and contrast the ecological levels within an ecosystem*** ● ***Classify examples of symbiotic relationships*** ● ***List and analyze ways that living things interact with each other in their environment*** ● ***Develop solutions to reverse the negative impacts of human activities on the environment***		*ASSESSMENT ITEMS: As a result of understanding the ideas and/or being skilled at the processes identified in 3.0 the student will:* ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content	
Score 2.0	*No major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes* **With assistance, can:** ● ***Analyze how abiotic and biotic factors influence the population size of organisms within an ecosystem*** ● ***Compare and contrast the ecological levels within an ecosystem*** ● ***Classify examples of symbiotic relationships*** ● ***List and analyze ways that living things interact with each other in their environment*** ● ***Develop solutions to reverse the negative impacts of human activities on the environment***		*2.0 ASSESSMENT Items: As a result of knowing the details and/or being skilled at the processes identified in 2.0 the student is able to:* ●

	1.5	Partial knowledge of the 2.0 content but major errors or omissions regarding the 3.0 content	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content but not the 3.0 content	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Earth and Space Science ***Course Overview***	
Grade level(s): 8	
Course Rationale	**Course Description:**
The middle school performance expectations in Earth and Space Science build on the elementary school ideas and skills which allow middle school students to explain more in-depth phenomena central to the earth and space sciences.	This course seeks to understand the Earth and its neighbors in space. The main purpose of Earth Science is to introduce students to the Earth and the intricate workings of our Earth's systems. Weather and earth's atmosphere, Earth's changing surface, rocks and minerals, environmental issues, and astronomy are all covered as part of this class.
Transfer Goals/Big Ideas	

<u>Transfer Goals (Science & Engineering Practices)</u>

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence
- Obtaining, Evaluating, and Communicating Information

<u>Big Ideas</u>

Earth Science is broken down into two core concepts: Earth's Place in the Universe and Earth's Systems and Human Activity.

Earth's Place in the Universe

- Gravity impacts the motions of objects in the universe.
- The universe has observable properties and structures.
- Earth and its Solar System are part of the Milky Way Galaxy, which is one of many galaxies in the universe.
- Humans have been investigating space for centuries and technological advancements have helped us study space.
- Patterns of the apparent motion of the sun, the moon can be explained with models.
- Earth's axis is fixed in direction in space, but tilted relative to its orbit around the sun.

- The seasons are a result of Earth's tilt and are caused by the varying intensity of sunlight on different areas of Earth across the year.
- The structure of the solar system can explain eclipses of the sun and the moon.

Earth's Systems and Human Activity

- The transfer of energy results in the movement of water through Earth's systems
- Water changes form throughout the water cycle
- Earth's materials are limited
- Climate is influenced by many different factors
- The ocean exerts a major influence on climate
- Earth's climate has changed over time
- Complex patterns of air and water movement are major determinants of local weather patterns
- Weather can only be predicted probabilistically
- Technology helps us understand and predict natural hazards
- Earth's materials are recycled throughout earth systems
- Earth's energy and resources are distributed unevenly
- Water's movement changes surface features and underground formations
- Geoscience processes can change earth's surface at varying time scales
- Human population and consumption of natural resources impact earth systems
- Internal processes impact earth's surface
- Plate movement can cause events that impact the other earth systems
- Layers of rock provide a way to organize Earth's history.
- Studying rock layers and fossils help us have a relative understand of Earth's age
- Geoscience processes can change earth's surface at varying time scales
- Water's movement changes surface features and underground formations

Priority Missouri Learning Standards/National Standards

- **6-8.ESS1.A.3** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- **6-8.ESS1.A.1:** Develop and use a model of the Earth-sun-moon to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
- **6-8.ESS2.C.1** Design and develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- **6-8.ESS2.C.3** Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- **6-8.ESS2.C.2** Research, collect, and analyze data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Course Name:

- **6-8.ESS2.B.1** Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
- **6-8.ESS2.A.1** Develop and use a model to illustrate that energy from the Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering and deformation of large rock formations, including generation of ocean seafloor at ridges, submergence of ocean seafloor at trenches, mountain building and active volcanic chains.
- **6-8.ESS1.C.1** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

Course Name:

Unit 1: Gravity and Our Solar System
Desired Results

Standards	Transfer Goal(s) /Big Ideas
6-8.ESS1.A.3 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. **Substandards** Analyze and interpret data to determine scale properties of objects in the solar system. **(6-8.ESS1.B.1**)	**Transfer Goals (Science & Engineering Practices):** ● Developing and Using Models ● Analyze and interpret data **Big Ideas** ● Gravity impacts the motions of objects in the universe. ● The universe has observable properties and structures. ● Earth and its Solar System are part of the Milky Way Galaxy, which is one of many galaxies in the universe. ● Humans have been investigating space for centuries and technological advancements have helped us study space.

Enduring Understandings	Essential Questions
● Gravity is a force of attraction between objects in the solar system that governs their motion. ● The Earth has a specific location in space, relative to the Sun and other celestial objects. ● Celestial objects are classified based on their compositional characteristics, including but not limited to internal structure, external structure, size, natural satellites, and atmosphere.	**1. Why do we explore outer space?** **2. How does gravity impact objects in space?** **3. How can we classify celestial bodies in the solar system into categories?** 4. **How have technological advancements throughout history helped us study space?**

Course Name:

Learning Targets
1. Students identify advances in solar system science made possible by improved engineering. 2. Students develop a model to identify that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects. 3. Students will be able to analyze patterns within given data to draw conclusions about the identifying characteristics (features, composition, and location) of different categories of objects within the Solar System.
Unit Duration:
10 days

Course Name:

Unit 2: The Sun-Earth-Moon System
Desired Results

Standards	Transfer Goal(s) /Big Ideas
6-8.ESS1.A.1: Develop and use a model of the Earth-sun-moon to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. **Substandards** Develop and use a model of the Earth-sun system to explain the cyclical pattern of seasons, which includes the Earth's tilt and directional angle of sunlight on different areas of Earth across the year. (**6-8.ESS1.A.2**)	**Transfer Goals (Science & Engineering Practices):** ● Developing and Using Models ● Constructing Explanations and Designing Solutions **Big Ideas** ● Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. ● Earth's axis is fixed in direction in space, but tilted relative to its orbit around the sun. ● The seasons are a result of Earth's tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. ● The structure of the solar system can explain eclipses of the sun and the moon.

Enduring Understandings	Essential Questions
● Light from the Sun bounces off the moon and is viewed on Earth as the bright part of the moon. The visible proportion of the illuminated part of the moon (as viewed from Earth) changes over the course of a month as the location of the moon relative to Earth and the sun changes. ● Solar energy is prevented from reaching the Earth during a solar eclipse because the moon is located between the sun and	**1. How do the orbits and relative positions of the Sun, Earth, Moon system produce eclipses?** **2. Why does the amount of daylight change throughout the year?** 3. **Why does the Moon's shape appear to change every month?**

	Earth. Solar energy is prevented from reaching the moon (and thus reflecting off of the moon to Earth) during a lunar eclipse because Earth is located between the sun and moon. ● The change in season at a given place on Earth is directly related to the orientation of the tilted Earth and the position of Earth in its orbit around the sun because of the change in the directness and intensity of the solar energy at that place over the course of the year.	

Learning Targets

1. Students will be able to illustrate the motions of the Sun, Earth and the Moon to describe axial rotation and revolution orbit to explain phenomena of day and night and year length, as well as the amount of time it takes to complete each motion.
2. Students will be able to develop a model to explain how Earth's tilt and orbital position around the Sun can cause a difference in seasons due to the changes in the intensity of sunlight on different parts of the Earth.
3. Students will be able to describe the position of the Earth, Moon, and Sun during both a solar and lunar eclipse.
4. Students will be able to describe how the appearance of the Moon that can be seen from Earth changes approximately every 28 days in an observable pattern (lunar phases).

Unit Duration:

10 days

Unit 3: Water Cycle
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">6-8.ESS2.C.1
Design and develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Substandards
Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes. (6-8.ESS3.A.1)

Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (6-8.ESS3.C.1)

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. (6-8.ESS3.C.2)</td><td colspan="2"><u>Transfer Goals (Science & Engineering Practices):</u>
● Developing and Using Models

<u>Big Ideas</u>
● The transfer of energy results in the movement of water through Earth’s systems
● Water changes form throughout the water cycle
● Earth’s materials are limited</td></tr>
<tr><td>Enduring Understandings
● Students can use a model to show energy from the sun and the force of gravity that drives water between oceans, the atmosphere, and land.
● Earth’s materials are limited natural resources affected by human activity.</td><td>Essential Questions
1. How does water change as it travels through the water cycle?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">1. Students will develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
2. Students will be able to describe the relationship between energy transfer and the processes of the water cycle.
3. Students will provide examples of how the availability of freshwater for humans and other living organisms is dependent upon the water cycle.
4. Describe the effect of human activities (e.g.; landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water.</td></tr>
</table>

Course Name:

Unit Duration:
10 days

Unit 4: Earth's Climate
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">6-8.ESS2.C.3 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Substandards
Analyze evidence of the factors that have caused the change in global temperatures over the past century. (6-8.ESS3.D.1)</td><td colspan="2"><u>Transfer Goals (Science & Engineering Practices):</u>
● Developing and Using Models
● Asking Questions and Defining Problems

<u>Big Ideas</u>
● Climate is influenced by many different factors
● The ocean exerts a major influence on climate
● Earth's climate has changed over time</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Climate is a description of average weather conditions in a given area over time due to the transfer of energy and matter through Earth's systems.
● Climate is influenced by sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
● The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.</td><td>1. What are some of the factors that influence a region's climate?
2. How do climates differ around the world?
3. If climate has changed throughout the earth's history, why is there so much concern about climate change today?</td></tr>
</table>

Course Name:

	● Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's surface temperature. ● Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	

Learning Targets

1. Students will create a model of ocean currents across the globe and relate how ocean currents can moderate climate.
2. Students will compare and contrast the climate zones for regions based upon altitude, latitude, and proximity to bodies of water.
3. Students will identify and describe the factors affecting the curved motion of wind and currents.
4. Students will be able to analyze current evidence about greenhouse gases, and causes of major changes in climate due to global warming.
5. Students will analyze data that connects natural processes, human activities, and the concentration of carbon dioxide and other greenhouse gases, to changes in global temperatures over the past century.

Unit Duration:

14 days

Course Name:

Course Name:

Unit 5: Weather
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">6-8.ESS2.C.1
Research, collect, and analyze data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Substandards
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (6-8.ESS3.B.1) Substandard</td><td colspan="2"><u>Transfer Goals (Science & Engineering Practices):</u>
● Planning and Carrying Out Investigations
● Developing and Using Models
● Analyzing and Interpreting Data

<u>Big Ideas</u>
● Complex patterns of air and water movement are major determinants of local weather patterns
● Weather can only be predicted probabilistically
● Technology helps us understand and predict natural hazards</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.
● Energy from the sun drives many different interactions within Earth’s systems that affect weather patterns.
● Because weather patterns are so complex, weather can only be predicted probabilistically.
● Storms are the result of interactions between moving air masses, high and low pressure systems, and frontal boundaries.</td><td>1. How does sunlight, Earth’s surface, and the atmosphere work together to create conditions that influence weather?
2. How do air masses and weather fronts interact in order to influence different types of weather?
3. What are the characteristics that contribute to severe weather patterns?</td></tr>
</table>

	● Scientists use scientific instruments in a wide variety of applications and they are incorporated with computers in order to help forecast the locations and likelihoods of future catastrophic events.	

Learning Targets

1. Students will carry out investigations about changes in weather and examine how weather is influenced by interactions involving sunlight, winds, landforms, ocean temperatures and currents, and the movement of water throughout Earth's systems.
2. Students analyze cause-and-effect relationships that help meteorologists make weather predictions and explore how mathematical models are used to predict weather to a certain degree of probability.
3. Students will make a claim about the weather factors that contribute to a severe weather event, using evidence from their research and model.

Unit Duration:

14 days

Unit 6: Surface Processes
Desired Results

Standards	Transfer Goal(s) /Big Ideas	
6-8.ESS2.A.1 Develop and use a model to illustrate that energy from the Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering and deformation of large rock formations, including generation of ocean seafloor at ridges, submergence of ocean seafloor at trenches, mountain building and active volcanic chains. **Substandards** Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. (**6-8.ESS3.A.1**) Substandard Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (**6-8.ESS2.A.2**) Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (**6-8.ESS3.C.1**)	**<u>Transfer Goals (Science & Engineering Practices):</u>** ● Developing and Using Models ● Constructing Explanations and Designing Solutions ● Engaging in Argument from Evidence **<u>Big Ideas</u>** ● Earth's materials are recycled throughout earth systems ● Earth's energy and resources are distributed unevenly ● Water's movement changes surface features and underground formations ● Geoscience processes can change earth's surface at varying time scales ● Human population and consumption of natural resources impact earth systems	
	Enduring Understandings	**Essential Questions**
	● All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. ● The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.	**1. How does classification help us understand the variety and complexity of Earth's materials?** **2. How have internal and external forces shaped Earth's surface over time?** **3. How have humans affected the rate of natural resource consumption and impacted Earth's systems?**

	● Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. ● Water's movements – both on the land and underground – cause weathering and erosion, which change the land's surface features and create underground formations. ● Minerals and geosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. ● As human populations and consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	

Learning Targets

1. Students will construct an explanation for how rock formations and other matter on Earth's surface have changed over time through chemical and physical processes.
2. Students can model the effects of erosion and deposition by water and wind.
3. Students can develop a model demonstrating the cycling of matter, the formation of rocks and minerals, and identifying the geologic forces that change these materials.
4. Students will use evidence to explain that humans depend on limited natural resources that may or may not be renewed over human lifetimes.

Unit Duration:

22 days

Course Name:

Unit 7: Earth's Interior
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">6-8.ESS2.B.1 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Substandards
Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (6-8.ESS3.B.1)</td><td colspan="2"><u>Transfer Goals (Science & Engineering Practices):</u>
● Analyzing and Interpreting Data

<u>Big Ideas</u>
● Internal processes impact earth's surface
● Plate movement can cause events that impact the other earth systems
● Technology helps us understand and predict natural hazards</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● There is evidence that shows that Pangea once existed and that the tectonic plates have moved and will continue to move over time.
● Uneven heating inside the mantle results in the melting of rock materials, convection of magma, eruption/flow of magma, and movement of crustal plates.
● Although we cannot see inside the Earth, we can predict what is going on beneath the surface based on observations of events on Earth's surface.</td><td>1. How do observations above the Earth's surface help scientists predict what is happening below the surface?
2. From one single supercontinent to the seven continents that exist today, how do we use clues from the present to understand how the Earth's geography has changed over its nearly 5 billion year history?
3. How do the Earth's landforms, such as volcanoes and mountains form over time?
4. How have geological hazards impacted past and current civilizations?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
</table>

Course Name:

1. Students will be able to describe the different ways that tectonic plates interact with one another and what happens as a result. 2. Students will be able to describe how properties of matter(density) impacts Earth's internal structure. 3. Students will be able to describe how tectonic plate movement is powered by internal processes and sources of energy within the Earth. 4. Students will be able to organize and analyze data that represents a natural hazard associated with plate tectonics including location, frequency, severity and types of damage.
Unit Duration:
20 days

Course Name:

Unit 8: Earth's History
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">6-8.ESS1.C.1 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

Substandards
Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. 6-8.ESS2.A.2</td><td colspan="2"><u>Transfer Goals (Science & Engineering Practices):</u>
● Developing and Using Models
● Analyzing and Interpreting Data
● Construction Explanations
● Obtaining, Evaluating, and Communicating Information

<u>Big Ideas</u>
● Layers of rock provide a way to organize Earth's history.
● Studying rock layers and fossils help us have a relative understand of Earth's age
● Geoscience processes can change earth's surface at varying time scales
● Water's movement changes surface features and underground formations</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The geologic time scale interpreted from rock strata provides a way to organize Earth's history. The fossil record shows how life has changed over time, including climatic changes, volcanism, meteorite impacts, and changing sea levels.
● Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.
● The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.</td><td>1. What kinds of evidence can give you clues about Earth's past?
2. How are the environment of an area and the organisms that live there related?</td></tr>
</table>

Course Name:

	● Water's movements – both on the land and underground – cause weathering and erosion, which change the land's surface features and create underground formations.	
Learning Targets		
1. Students will be able to determine the ages of Earth's rocks and fossils using relative dating methods. 2. Students will analyze evidence used to organize Earth's long history. 3. Students will obtain and evaluate evidence about geologic processes, rocks, and fossils to construct explanations for how Earth's history is organized into the geologic time scale.		
Unit Duration:		
10 days		

6-8.ESS1.A.3			
Topic: Gravity and Our Solar System			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● identify advances in solar system science made possible by improved engineering. ● develop a model to identify that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects. ● analyze patterns within given data to draw conclusions about the identifying characteristics (features, composition, and location) of different categories of objects within the Solar System.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● identify advances in solar system science made possible by improved engineering. ● develop a model to identify that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects. ● analyze patterns within given data to draw conclusions about the identifying characteristics (features, composition, and location) of different categories of objects within the Solar System.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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6-8.ESS1.A.1			
Topic: The Sun-Earth-Moon System			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● illustrate the motions of the Sun, Earth and the Moon to describe axial rotation and revolution orbit to explain phenomena of day and night and year length, as well as the amount of time it takes to complete each motion. ● develop a model to explain how Earth's tilt and orbital position around the Sun can cause a difference in seasons due to the changes in the intensity of sunlight on different parts of the Earth. ● describe the position of the Earth, Moon, and Sun during both a solar and lunar eclipse. ● describe how the appearance of the Moon that can be seen from Earth changes approximately every 28 days in an observable pattern (lunar phases).		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● illustrate the motions of the Sun, Earth and the Moon to describe axial rotation and revolution orbit to explain phenomena of day and night and year length, as well as the amount of time it takes to complete each motion. ● develop a model to explain how Earth's tilt and orbital position around the Sun can cause a difference in seasons due to the changes in the intensity of sunlight on different parts of the Earth. ● describe the position of the Earth, Moon, and Sun during both a solar and lunar eclipse. ● describe how the appearance of the Moon that can be seen from Earth changes approximately every 28 days in an observable pattern (lunar phases).		

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	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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6-8.ESS2.C.1			
Topic: Water Cycle			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. ● describe the relationship between energy transfer and the processes of the water cycle. ● provide examples of how the availability of freshwater for humans and other living organisms is dependent upon the water cycle. ● describe the effect of human activities (e.g.; landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. ● describe the relationship between energy transfer and the processes of the water cycle. ● provide examples of how the availability of freshwater for humans and other living organisms is dependent upon the water cycle. ● describe the effect of human activities (e.g.; landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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6-8.ESS2.C.3			
Topic: Earth's Climate			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● create a model of ocean currents across the globe and relate how ocean currents can moderate climate. ● compare and contrast the climate zones for regions based upon altitude, latitude, and proximity to bodies of water. ● identify and describe the factors affecting the curved motion of wind and currents. ● analyze current evidence about greenhouse gases, and causes of major changes in climate due to global warming. ● analyze data that connects natural processes, human activities, and the concentration of carbon dioxide and other greenhouse gases, to changes in global temperatures over the past century.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● create a model of ocean currents across the globe and relate how ocean currents can moderate climate. ● compare and contrast the climate zones for regions based upon altitude, latitude, and proximity to bodies of water. ● identify and describe the factors affecting the curved motion of wind and currents. ● analyze current evidence about greenhouse gases, and causes of major changes in climate due to global warming.		

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	● analyze data that connects natural processes, human activities, and the concentration of carbon dioxide and other greenhouse gases, to changes in global temperatures over the past century.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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6-8.ESS2.C.1			
Topic: Weather			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● carry out investigations about changes in weather and examine how weather is influenced by interactions involving sunlight, winds, landforms, ocean temperatures and currents, and the movement of water throughout Earth's systems. ● analyze cause-and-effect relationships that help meteorologists make weather predictions and explore how mathematical models are used to predict weather to a certain degree of probability. ● make a claim about the weather factors that contribute to a severe weather event, using evidence from their research and model.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● carry out investigations about changes in weather and examine how weather is influenced by interactions involving sunlight, winds, landforms, ocean temperatures and currents, and the movement of water throughout Earth's systems. ● analyze cause-and-effect relationships that help meteorologists make weather predictions and explore how mathematical models are used to predict weather to a certain degree of probability. ● make a claim about the weather factors that contribute to a severe weather event, using evidence from their research and model.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
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6-8.ESS2.A.1			
Topic: Surface Processes			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● construct an explanation for how rock formations and other matter on Earth's surface have changed over time through chemical and physical processes. ● model the effects of erosion and deposition by water and wind. ● develop a model demonstrating the cycling of matter, the formation of rocks and minerals, and identifying the geologic forces that change these materials. ● use evidence to explain that humans depend on limited natural resources that may or may not be renewed over human lifetimes.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● construct an explanation for how rock formations and other matter on Earth's surface have changed over time through chemical and physical processes. ● model the effects of erosion and deposition by water and wind. ● develop a model demonstrating the cycling of matter, the formation of rocks and minerals, and identifying the geologic forces that change these materials. ● use evidence to explain that humans depend on limited natural resources that may or may not be renewed over human lifetimes.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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6-8.ESS2.B.1			
Topic: Earth's Interior			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● describe the different ways that tectonic plates interact with one another and what happens as a result. ● describe how properties of matter(density) impacts Earth's internal structure. ● describe how tectonic plate movement is powered by internal processes and sources of energy within the Earth. ● organize and analyze data that represents a natural hazard associated with plate tectonics including location, frequency, severity and types of damage.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● describe the different ways that tectonic plates interact with one another and what happens as a result. ● describe how properties of matter(density) impacts Earth's internal structure. ● describe how tectonic plate movement is powered by internal processes and sources of energy within the Earth. ● organize and analyze data that represents a natural hazard associated with plate tectonics including location, frequency, severity and types of damage.		
	1.5	Partial **knowledge** of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

6-8.ESS1.C.1			
Topic: Earth's History			
Grade: 8			
Score 4.0	**Student uses knowledge and inferences or applications beyond what was taught.**		**Sample Tasks**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	*No major errors or gaps in the following TARGETED, COMPLEX ideas and processes.* **Students will:** ● determine the ages of Earth's rocks and fossils using relative dating methods. ● analyze evidence used to organize Earth's long history. ● obtain and evaluate evidence about geologic processes, rocks, and fossils to construct explanations for how Earth's history is organized into the geologic time scale.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	*There are no major errors or gaps in the following FOUNDATIONAL, SIMPLE details and processes.* **With assistance, students can:** ● determine the ages of Earth's rocks and fossils using relative dating methods. ● analyze evidence used to organize Earth's long history. ● obtain and evaluate evidence about geologic processes, rocks, and fossils to construct explanations for how Earth's history is organized into the geologic time scale.		
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<table>
<tr><th colspan="2">PLTW Medical Detectives
Course Overview</th></tr>
<tr><td>Grade level(s): 7th Grade</td><td></td></tr>
<tr><td>Course Rationale</td><td>Course Description</td></tr>
<tr><td>Students become medical detectives and solve medical mysteries. They apply experimental design, creative thinking, and problem solving to investigate the inner-workings of the human body, diagnose disease, and improve human health.</td><td>In the PLTW Medical Detectives course, students play the role of real-life medical detectives as they collect and analyze medical data to diagnose disease. They solve medical mysteries through hands-on projects and labs, measure and interpret vital signs, dissect a sheep brain, investigate disease outbreaks, and explore how a breakdown within the human body can lead to dysfunction. Throughout the course, students discover how healthcare professionals act as medical detectives to identify, treat, and prevent illness in their patients. Students apply their knowledge of the human body systems, analyze patient symptoms, perform lab analyses of patient samples, and use other clues to come up with diagnoses.</td></tr>
<tr><td colspan="2">Transfer Goals/Big Ideas</td></tr>
<tr><td colspan="2">Big Ideas:
● Diagnosing, treating, and preventing illnesses requires analyzing vital signs, patient medical history, physical exams, and test results.
● The nervous system takes in information through our senses, processes the information and triggers reactions.
● When investigating disease outbreaks, epidemiologists look for patterns to prevent further illness.
Transfer Goals:
● Asking questions and defining problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data</td></tr>
</table>

- **Using mathematics and computational thinking**
- **Constructing explanations and designing solutions**
- **Engaging in an argument from evidence**
- **Obtaining, evaluating, and communicating information**

Priority Missouri Learning Standards/National Standards

Missouri Learning Standards

NGSS.P1 Asking Questions and Defining Problems - Ask Questions

- ***that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.***
- ***to identify and/or clarify evidence and/or the premise(s) of an argument.***
- ***to determine relationships between independent and dependent variables and relationships in models.***
- ***to clarify and/or refine a model, an explanation, or an engineering problem.***
- ***that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.***

NGSS.P2 Developing and Using Models

- ***Evaluate limitations of a model for a proposed object or tool.***
- ***Develop and/or use a model to predict and/or describe phenomena.***
- ***Develop a model to describe unobservable mechanisms.***

NGSS.P3 Planning and Carrying Out Investigations

- ***Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.***
- ***Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.***
- ***Evaluate the accuracy of various methods for collecting data.***
- ***Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.***

NGSS.P4 Analyzing and Interpreting Data

- ***Analyze and interpret data to provide evidence for phenomena.***
- ***Analyze and interpret data to determine similarities and differences in findings.***

NGSS.P5 Using Mathematics and Computational Thinking

- ***Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.***

NGSS.P6 Constructing Explanations and Designing Solutions

- ***Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.***
- ***Construct an explanation using models or representations.***
- ***Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.***

NGSS.P7 Constructing Explanations and Designing Solutions

- ***Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.***

NGSS.P8 Obtaining, Evaluating, and Communicating Information

- ***Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).***
- ***Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations***

6-8.LS1.A.1 - Provide evidence that organisms (unicellular and multicellular) are made of cells and that a single cell must carry out all of the basic functions of life.
6-8.LS1.A.2 - Develop and use a model to describe the function of a cell as a whole and ways parts of the cells contribute to that function.
6-8.LS1.A.4 - Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.

Unit 1: Disease Detectives

Desired Results

Course Name: PLTW Medical Detectives

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">Missouri Learning Standards (NGSS)
● 6-8.LS1.A.1
● 6-8.LS1.A.4
● NGSS.P1
● NGSS.P3
● NGSS.P4
● NGSS.P6
● NGSS.P7
● NGSS.P8</td><td colspan="2">Students discover how healthcare professionals act as medical detectives to identify, treat, and prevent illness in their patients. Students collect and interpret vital signs to evaluate patient health, explore different infectious disease agents, and design and conduct experiments to test the effectiveness of antibiotics on bacteria. In the end-of-lesson project, students collect and analyze medical data to diagnose a patient with a mystery illness.</td></tr>
<tr><td>Enduring Understandings
● Patient health can be evaluated in a variety of ways, including collecting a patient's medical history and testing vital signs.
● Medical professionals use a sequential, logical process to evaluate, diagnose, and treat patients.
● A variety of health care professionals and scientists investigate medical mysteries.</td><td>Essential Questions
1. What can patient signs and symptoms tell us about what’s happening in the human body?
2. How do medical detectives investigate their cases?
3. What does effective teamwork look like?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
● Collect and analyze vital signs to draw conclusions.
● Explain differences among vital sign readings.
● Use the experimental design process to investigate a question.
● Design and conduct an experiment to draw conclusions.
● Analyze a patient’s signs and symptoms to diagnose a problem.
● Design, document, and conduct an experiment to draw conclusions and provide treatment options.
● Explore how disease agents are transmitted and treated.</td></tr>
</table>

- Use aseptic technique to culture bacteria.
- Analyze a patient's medical file and physician notes to request and interpret lab tests.
- Identify the purpose of positive and negative controls.
- Conduct interviews to gather information.
- Provide a diagnosis and treatment for a patient based on test results, patient interviews, and medical file information.
- Collaborate within a team.
- Demonstrate effective communication skills.

Unit Duration:

6 weeks



Unit 2: Mysteries of the Human Body
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**	
Missouri Learning Standards *(NGSS)* ● ***6-8.LS1.A.2*** ● ***NGSS.P1*** ● ***NGSS.P2*** ● ***NGSS.P3*** ● ***NGSS.P4*** ● ***NGSS.P6*** ● ***NGSS.P7*** ● ***NGSS.P8***	This unit introduces the human body as a collection of body systems, with a focus on the nervous system. Students investigate how the nervous system collects information from the outside world, moves this information through neurons, processes this information in the brain, and initiates the body's response accordingly. Students create neuron models and perform a sheep brain dissection. They use their knowledge to explore symptoms as they relate to specific nervous system dysfunction and analyze evidence to identify the cause of the dysfunction. In the end-of-unit project, students create educational resources to help their patient understand the medical condition.	
	Enduring Understandings	**Essential Questions**

	● The nervous system collects and interprets input from the outside world using specialized receptors. ● The brain is a complex organ that is organized into specialized regions.	1. What can patient signs and symptoms tell us about what's happening in the human body? 2. How does the nervous system allow our bodies to interact with the outside world? 3. How do medical detectives investigate their cases? 4. What does effective teamwork look like?

Learning Targets

Students will…

- Describe how the nervous system works to sense, process, and respond to stimuli in the world.
- Identify the path of input and output signals through the nervous system.
- Describe the structure and function of neurons.
- Model how a signal is transferred through and among neurons.
- Explore types of neurological tests.
- Analyze a patient's medical file, physician notes, and medical examination tests to draw conclusions.
- Identify the communication breakdown of a nervous system dysfunction.
- Describe the structure and function of the brain and its parts.
- Compare human and sheep anatomy.
- Predict dysfunction based on the location of brain injury or disorder.
- Plan an investigation to solve a problem.
- Support the diagnosis with facts from the investigation.
- Collaborate within a team.
- Demonstrate effective communication skills.

Unit Duration:

8 weeks

Unit 3: Outbreak!
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">Missouri Learning Standards (NGSS)
● NGSS.P1
● NGSS.P3
● NGSS.P4
● NGSS.P5
● NGSS.P6
● NGSS.P7
● NGSS.P8</td><td colspan="2">A mysterious toxin is endangering the health of a community. Using their understanding of human body systems, students describe how the suspected toxin has impacted the health of the patient. Students analyze patient symptoms and perform lab analyses of patient samples to identify the culprit and determine how it’s spreading. In the end-of-unit problem, students locate the source of the toxin using a map of the community, patient histories, and lab data, then present their findings to help community leaders mitigate the situation.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● An epidemic is an infectious disease that spreads rapidly and sickens a large number of people.
● Rapid case detection and response are key to ending a disease outbreak through efficient surveillance and laboratory work, effective coordination and teamwork.</td><td>1. What can patient signs and symptoms tell us about what’s happening in the human body?
2. How does the nervous system allow our bodies to interact with the outside world?
3. How do medical detectives investigate their cases?
4. What does effective teamwork look like?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
</table>

Course Name: PLTW Medical Detectives

Students will… ● Organize and analyze data to calculate probability. ● Use attack rate calculations to determine the likely source of illness. ● Analyze medical evidence to determine the source of an outbreak. ● Develop and carry out a plan to determine the source of illness. ● Use evidence from an investigation to support a claim. ● Communicate effectively to the public about the source of the outbreak. ● Collaborate within a team.
Unit Duration:
4 weeks



Assessment Evidence

Rubric/Scoring	**Assessment**
Project 1.5: Diagnostic Detectives Summative Assessment Rubric *Project 2.5: Mystery Disease Summative Assessment Rubric* *Problem 3.2: Disease Detectives Summative Assessment Rubric*	● Formative assessments (1.5 Formative Assessment, 2.4 Control Center Assessment) ● Summative assessments (*Diagnostic Detectives*, *Mystery Disease*, *Disease Detectives*) ● Show criteria and models in advance ● Exit Tickets ● Conclusion Questions for each lesson ● Provide feedback early and often

Course Name: PLTW Medical Detectives

Learning Plan



Week(s)	Topic	Resources/Texts	Learning Targets	Assessment
6 weeks	Unit 1: Disease Detectives ● Activity 1.1: Vital Signs ● Activity 1.2: Exploring What's Vital ● Activity 1.3: Disease Agents - GloGerm Activity ● Activity 1.4: Disease Diagnosis ● Project 1.5: Diagnostic Detectives	● my.pltw.org ● https://human.biodigital.com/ ● blooket.com ● flocabulary.com ● classhook.com ● khanacademy.org ● cdc.gov ● quizlet.com ● edpuzzle.com ● contrib.pbslearningmedia.org ● www.purposegames.com ● kahoot.com	● Collect and analyze vital signs to draw conclusions. ● Explain differences among vital sign readings. ● Use the experimental design process to investigate a question. ● Design and conduct an experiment to draw conclusions. ● Analyze a patient's signs and symptoms to diagnose a problem. ● Design, document, and conduct an experiment to draw conclusions and provide treatment options. ● Explore how disease agents are transmitted and treated. ● Use aseptic technique to culture bacteria.	Conclusion Questions: ● Why is it necessary to check more than one vital sign on a patient? ● How might vital signs impact a medical professional's decisions as they investigate an illness? ● How might a scientist use experimental design to investigate the effect of a new medication on an organism that infects humans? ● How can well-designed experiments help medical detectives solve cases? ● The group next to you completed the same experiment, but forgot to use

			• Analyze a patient's medical file and physician notes to request and interpret lab tests. • Identify the purpose of positive and negative controls. • Conduct interviews to gather information. • Provide a diagnosis and treatment for a patient based on test results, patient interviews, and medical file information. • Collaborate within a team. • Demonstrate effective communication skills.	a control. Why is this a problem? • Your friend is complaining that he went to the doctor for a cold and the doctor did not prescribe him an antibiotic. Should you recommend that he see a different doctor? Why or why not? • Why are positive and negative controls important when analyzing patient lab results? 2. If you were Patient 1's physician, what would you tell her about the disease agent that caused the illness and how this illness was transmitted? • If you were your patient's physician, what would you tell the patient about the disease agent that caused the illness and how they could have prevented this illness? 1.5 Formative Assessment Project 1.5: Diagnostic Detectives Summative Assessment - Rubric

Course Name: PLTW Medical Detectives

8 weeks	Unit 2: Mysteries of the Human Body ● Activity 2.1: Secrets of the Nervous System ● Activity 2.2: Smart Signals ● Activity 2.3: Mysterious Miscommunications ● Activity 2.4: The Control Center ● Project 2.5: Mystery Disease	● my.pltw.org ● https://human.biodigital.com/ ● blooket.com ● edpuzzle.com ● https://faculty.washington.edu/chudler/neurok.html ● ezgif.com ● ed.ted.com ● quizlet.com ● gimkit.com ● discoveryeducation.com ● mysteryscience.com ● news24.com ● www.purposegames.com	● Describe how the nervous system works to sense, process, and respond to stimuli in the world. ● Identify the path of input and output signals through the nervous system. ● Describe the structure and function of neurons. ● Model how a signal is transferred through and among neurons. ● Explore types of neurological tests. ● Analyze a patient's medical file, physician notes, and medical examination tests to draw conclusions. ● Identify the communication breakdown of a nervous system dysfunction. ● Describe the structure and function of the brain and its parts. ● Compare human and sheep anatomy. ● Predict dysfunction based on the location of brain injury or disorder.	Conclusion Questions ● How do our bodies receive stimuli as input, and what part of the nervous system is responsible for that process? ● How does the entire nervous system allow our bodies to interact with our world? Your response must include the following terms: ○ peripheral nervous system ○ central nervous system ○ sensory neurons ○ motor neurons ● How do you think a problem with the sensory or motor neurons might affect your body? ● Briefly describe how signals move through and between neurons. ● What might happen if a neuron is unable to accurately pass signals? ● What event do you think might have caused Patient 1's condition?

			• Plan an investigation to solve a problem. • Support the diagnosis with facts from the investigation. • Collaborate within a team. • Demonstrate effective communication skills.	• Why could an incomplete medical file be a problem when diagnosing neurological disorders? • Cerebral palsy is a condition that affects body movement and coordination. It's caused by brain injury or brain malformation that occurs before, during, or immediately after birth when an infant's brain is still developing. Which area or part of the brain is likely affected in a person with cerebral palsy who has movement problems in their right arm and hand? Explain your answer. • Return to the first paragraph of The Amazing Brain section and re-read the description of the baseball pitcher. Which brain region or part is responsible for this pitcher's experience? • Why is it important to communicate information clearly and completely with patients?

				• A man who's been battling lung cancer for the last three months is now experiencing personality changes and memory problems. Describe some of the different professionals who might be needed to diagnose and treat this man. 2.4 Control Center Assessment Project 2.5: Mystery Disease Summative Assessment - Rubric

Course Name: PLTW Medical Detectives

4 weeks	Unit 3: Outbreak! ● Activity 3.1: Food Fiasco ● Problem 3.2: Disease Detectives	● my.pltw.org ● kahoot.com ● quizizz.com ● gimkit.com ● blooket.com ● discoveryeducation.com ● cdc.gov ● sciencejournalforkids.org ● https://faculty.washington.edu/chudler/neurok.html ● playfactile.com ● flip	● Organize and analyze data to calculate probability. ● Use attack rate calculations to determine the likely source of illness. ● Analyze medical evidence to determine the source of an outbreak. ● Develop and carry out a plan to determine the source of illness. ● Use evidence from an investigation to support a claim. ● Communicate effectively to the public about the source of the outbreak. ● Collaborate within a team.	Conclusion Questions: ● What medical evidence can epidemiologists use to investigate the source of a foodborne illness? ● Besides helping to identify the source of foodborne illnesses and preventing their impact, what other ways might epidemiologists assist in keeping the public safe from disease? ● Why is it important for medical detectives to collect and analyze a variety of evidence to investigate a problem? ● Why is it important to keep the public informed of an outbreak with timely and accurate updates? Problem 3.2: Disease Detectives Summative Assessment - Rubric

Physical Science ***Course Overview***	
Grade level(s): 9	**Credits earned:** 1 Unit
Course Rationale	**Course Description**
Scientists use experiments to investigate the universe by collecting data to create mathematical models to explain and predict what they see. This course will help students develop the skills needed to be scientists. Students seeking careers in the STEM fields will need the skills taught in physical science to be successful in these fields.	*Physical Science is an introductory science course designed to familiarize the student with concepts of matter, forces, and energy in the universe. Emphasis is on scientific literacy and hands-on investigation.*
Transfer Goals/Big Ideas	
● Asking Questions and Defining Problems ● Developing and using models (verbal, mathematical and graphical) ● Planning and carrying out investigations ● Analyzing and interpreting data tables and graphs ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information	
Priority Missouri Learning Standards/National Standards	
● Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject	

to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] (9-12.PS2.A.1)

- Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] (9-12.PS3.A.1)
- Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (9-12.PS2.B.2)
- Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). (9-12.PS1.A.3)
- Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] (9-12.PS3.B.1)
- Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media (9-12.PS4.A.1).
- Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] (9-12.PS4.A.2)

<table>
<tr><th colspan="3">Unit 1: Experimental Design
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">● PS1.A.1
● PS1.A.3
● PS1.B.1
*These standards will not be explicitly addressed in this unit, but the skills and processes necessary to master them (such as experimental design, data collection, data / graphical analysis, model building, etc.) will be taught to students.</td><td colspan="2">● Scientists use experiments to investigate the universe.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.
● Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
● Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understanding)
● The nature of science relies upon communication of results and justification of explanations.</td><td>1. How do scientists design experiments?
2. How do scientists determine if something is “true”?
3. How and why do scientists model what happens in the real world?
4. Can students use the scientific equipment effectively as well as make metric conversions?
5. Can the student set up a valid experiment including essential components?</td></tr>
</table>

Learning Targets
Students will… ● *Conduct an experiment while following safety protocol.* ● *Be able to identify variables and constants* ● *Associate units to quantities* ● *Construct a data table Create graphs to represent data (graphs should include title, labeled axis)* ● *Write a detailed procedure and conclusion* ● *Use dimensional analysis to effectively convert units (metric and standard)*
Unit Duration:
Year long. This unit will focus on the basics of designing, conducting and analyzing experiments. Students will be implementing these standards in every unit for the duration of the course.

<table>
<tr><th colspan="3">Unit 2: Mechanics (Newton's Laws of Motion)
Desired Results</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">PS2.A.1
PS2.A.2
PS2.A.3</td><td colspan="2">The motion of an object is determined by its change in position relative to another object or point.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>Students will understand motion relative to a frame of reference.
Students will be able to represent the motion of an object by looking at a position/acceleration vs. time graph.
Students will be able to determine net force acting on an object and whether or not the object is accelerating according to Newton's 1st Law.</td><td>How can the motion of an object be described?
How does slope represent the state of motion of an object?
How is acceleration for an object represented graphically compared to constant velocity?
How can Newton's Laws be used to explain the current state of motion for an object?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
Calculate acceleration, speed and velocity
Associate units with quantities
Determine motion for an object graphically
Identify the state of equilibrium for an object Determine direction of an object (positive and negative)
Be able to graph the motion of an object</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">4-6 Weeks</td></tr>
</table>

<table>
<tr><th colspan="3"> 
Unit 3: Forces
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● PS2.A.1
● PS2.A.2
● PS2.A.3</td><td colspan="2">● Forces affect motion</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Forces are classified as either contact forces (pushes, pulls, friction, buoyancy) or non-contact forces (gravity, magnetism), that can be described in terms of direction and magnitude.
● Every object exerts a gravitational force on every other object
● Newton’s Laws of Motion explain the interaction of mass and forces, and are used to predict changes in motion
● Perpendicular forces act independently of each other</td><td>1. What is the difference between mass and weight?
2. How does mass and force affect the acceleration of an object?
3. What factors affect gravitational forces?
4. What are the forces acting on an object? Does this cause the object to speed up, slow down, change directions, or remain at rest.
5. How does the net force acting on an object result in its change in motion?
6. What are action/reaction pairs in any example of an object?</td></tr>
</table>

Learning Targets
Students will… ● *Conduct an experiment while following safety protocol.* ● *Associate units to quantities* ● *Students should be able to calculate weight from mass* ● *Students should be able to use Newton's 2nd law equation.* ● *Predict the state of motion for an object* ● *Be able to diagram forces acting on an object* ● *Be able to identify action/reaction pairs*
Unit Duration:
6 Weeks

<table>
<tr><td colspan="3"> 
Unit 4: Momentum
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">PS2.A.2
PS2.A.3</td><td colspan="2">The motion of an object is described by its change in position relative to another object or point.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>Momentum depends on the mass of the object and the velocity with which it is traveling</td><td>What are the factors that affect momentum?
How can the momentum of an object be changed?
How is momentum conserved?
What are the different types of collisions?
What steps are necessary to calculate momentum or the unknown variable using the momentum equation?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
Calculate momentum for an object
Describe how the factors of impulse result in momentum change
Identify a collision as elastic or inelastic
Solve for unknown variables using conservation of momentum equations
Explain the change in velocity as a result of a collision based on the law of conservation principle.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">4-6 Weeks</td></tr>
</table>

Unit 5: Work, Power, and Energy
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">

- *PS3.A.1*
- *PS3.A.2*
- *PS3.A.3*

</td><td colspan="2">

- *Energy has a source, can be stored, and can be transferred but is conserved within a system.*
- *Forces affect motion*

</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>

- *Forms of energy have a source, a means of transfer (work and heat), and a receiver*
- *Mechanical energy comes from the motion (kinetic energy) and/or relative position (potential energy) of an object*
- *Energy can be transferred within a system as the total amount of energy remains constant (i.e., Law of Conservation of Energy)*
- *Work transfers energy into and out of a mechanical system*

</td><td>

1. **How can we identify when work has been done?**
2. **What is the relationship between work and power?**
3. **How do simple machines make work easier?**
4. **What are the various forms of energy?**
5. **How does energy take on various forms based on the Law of Conservation of Energy?**

</td></tr>
</table>

Learning Targets
Students will… ● *Students will design or implement a lab experiment using simple machines to calculate work done, efficiency, mechanical advantage and other ways of measuring a machine's effectiveness.* ● *Apply the definition of work to everyday scenarios.* ● *Determine the power output for a simple machine.* ● *Identify the energy transformations that take place in a system.* ● *Calculate the amount and types of energy that exist at various stages.*
Unit Duration:
4-6 Weeks

<table>
<tr><th colspan="3">Unit 6: Electricity and Magnetism
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● PS2.B.2</td><td colspan="2">● Changes in properties and states of matter provide evidence of the atomic theory of matter
● Forces affect motion</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The atomic model describes the electrically neutral atom
● Magnetic forces are related to electrical forces as different aspects of a single electromagnetic force</td><td>1. What is the structure of an atom?
2. What gives an element its properties?
3. Why are electrons, rather than protons, the principal charge carriers in metal wires?
4. What factors contribute to static electricity?
5. What effect does applying resistance do to the electric current?
6. If the voltage impressed across a circuit is held constant while the resistance doubles, what change occurs in the current?
7. How do the different circuits cause different amounts of current?
8. Why are some pieces of iron magnets and others are not?
9. What factors increase the strength of an electromagnet?
10. What is the relationship between current and magnetism</td></tr>
</table>

Learning Targets
Students will… ● *Identify subatomic particles and their charges in an atom* ● *Explain how static electricity occurs in detail* ● *Predict if attraction or repulsion will occur between two charges* ● *Be able to explain how an electrically charged object can be attracted to a neutral object* ● *Understand that in order to have an electrical current an electrical potential (voltage) must be present* ● *Use ohm's law to calculate for unknown variables in a circuit* ● *Be able to identify characteristics of a series and parallel circuit* ● *Be able to draw schematic diagrams of the two types of simple circuits* ● *Find the current, voltage and resistance in a circuit* ● *Explain why some pieces of iron can become magnetic*
Unit Duration:
4-6 Weeks

<table>
<tr><th colspan="3">Unit 7: Heat and Thermal Energy
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">PS1.A.3
PS3.B.1</td><td colspan="2">Changes in properties and states of matter provide evidence of the atomic theory of matter
Energy has a source, can be stored, and can be transferred but is conserved within a system</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>Physical changes in states of matter due to thermal changes in materials can be explained by the Kinetic Theory of Matter
Forms of energy have a source, a means of transfer (work and heat) and a receiver</td><td>What is the difference between heat, temperature and thermal energy?
How is temperature measured? (3 scales)
Why do some objects heat up or cool down faster than others?
Why doesn’t temperature change when undergoing a phase change?
Why is evaporation a cooling process and condensation a warming process?
What are the different types of heat transfer?
What is thermal equilibrium?
How does thermal expansion affect certain objects? How is water different from other objects?</td></tr>
</table>

Learning Targets
Students will… ● *Explain the difference between thermal energy, heat and temperature .* ● *Distinguish between a heat conductor and insulator.* ● *Use a graph to explain that when the energy of the particles making up a substance changes, either the temperature must change or the phase, but not both at the same time.* ● *Convert between Celsius, Fahrenheit and Kelvin scales.* ● *Calculate energy using the specific heat equation.* ● *Determine the change in temperature using the principle that heat is neither gained nor lost.* ● *Explain water's role in climate*
Unit Duration:
4-6 Weeks

<table>
<tr><th colspan="3">Unit 8: Waves
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● PS4.A.1
● PS4.A.2</td><td colspan="2">● Energy has a source, can be stored, and can be transferred but is conserved within a system</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Forms of energy have a source, a means of transfer (work and heat) and a receiver
● Electromagnetic energy from the Sun (solar radiation) is a major source of Energy on Earth</td><td>1. What are the main types of waves?
2. How does a mechanical wave compare/contrast to an electromagnetic wave?
3. What causes waves?
4. What determines the frequency of a wave?
5. How does changing the medium of a wave affect the speed?
6. How is the amplitude of a wave related to the energy in a wave?
7. What is a standing wave? Are standing waves a property of transverse waves, of longitudinal waves, or of both?
8. Distinguish between constructive interference and destructive interference.
9. How is frequency related to pitch in a sound wave?
10. What are overtones?</td></tr>
</table>

Learning Targets
Students will… ● *Identify characteristics of a transverse wave (wavelength, amplitude, crest and trough).* ● *Identify characteristics of a longitudinal wave (compressions and rarefactions).* ● *Find the frequency and period in a wave.* ● *Knowing wavelength and frequency solve for the speed of a wave.*
Unit Duration:
4-6 Weeks

Strand : PS1.A.1			
Topic: Experimental Design			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** ● Will be able to identify mass number and net charge of various elements. **The student exhibits no major errors or omissions.**		● Students are given diagrams to identify the position of the subatomic particle within an atom. ● Students are given varying amounts of protons, neutrons, and electrons to determine the mass number or other unknown values.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Will be able to identify charges and position of subatomic particles and how it relates to different elements. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS1.B.1			
Topic: Experimental Design			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** ○ Can design a valid experiment, (correctly identifying Ind/Dep variable and what variables must be held constant) and describe the experimental procedure clearly. **The student exhibits no major errors or omissions.**		● Students can read a given procedure and evaluate if the experiment is valid. ● Given a hypothesis, students can formulate a valid experiment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: o Independent and dependent variables, controls, constants ● Performs basic processes, such as: o Identifying the above terms when given a procedure. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS1.A.3			
Topic: Experimental Design			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.** ○ The students will be able to use scientific equipment to measure quantities using metric units. ○ Students will include correct units on all answers / measurements. ○ Students will be able to construct a useful data table and generate a graph from the data. **The student exhibits no major errors or omissions.**		● Given objects, students will be able to find mass, volume, length and density ● Conduct a lab to acquire data and graph said data.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: ○ graduated cylinder, metric ruler, triple beam balance ● Performs basic processes, such as: ○ identify the lab equipment associated with the quantities ● Recognizes or recalls specific terminology, such as: o axes, best fit line ● Performs basic processes, such as:		● Identifying the equipment associated with the measurement ● Given a blank data table or graph, students can apply labels

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	o Labeling and titling a graph and data table **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS2.A.3			
Topic: Motion and Newton's 1st Law			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** ○ Students will be able to understand motion relative to a frame of reference and can differentiate velocity from acceleration. Students can use this understanding to perform basic calculations to find speed, distance, and acceleration. ○ Students will be able to represent the motion of an object graphically or describe the motion of an object by looking at a position/velocity vs. time graph. **The student exhibits no major errors or omissions.**		● Given an object in motion, identify the frame of reference ● Determine if an object is accelerating through calculations. ● Given data students can construct appropriate graphs and find their slope. ● Given graphs, students can describe the motion of an object.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: o velocity, acceleration, frame of reference, ● Performs basic processes, such as: o connects values to quantities o recognizes which equation to apply		● Identify values in relation to the quantities they represent ● Can recall basic equations.

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	● Can differentiate between graphs of constant and non-constant velocity. ● Know which direction an object is moving based on a graph of its motion. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS2.A.1			
Topic: Newton's 1st and 2nd Laws			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** ○ Students will be able to determine net force acting on an object and whether or not an object is accelerating according to Newton's First Law. ○ Students will understand the relationship between mass, net force and acceleration and can use this understanding to predict the behavior of an object under the influence of one or several forces. **The student exhibits no major errors or omissions.**		● Draw / interpret force diagrams of different scenarios. ● Find the net force given a force diagram. ● Observe and describe the motion of a HoverPuck. ● Solve for net force, mass, and/or acceleration using Newton's 2nd Law.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can state Newton's 1st Law. ● Can apply Newton's 1st Law for a stationary or moving object. ● Can define equilibrium ● Can recall Newton's 2nd Law. ● General understanding of relationship between net force / mass and acceleration. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Give examples of relationship (e.g. a loaded car doesn't accelerate as much as an empty car)
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand : PS2.A.2			
Topic: Newton's 2nd & 3rd Law			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system.** ● Students will identify the different types of forces that act on an object and know factors that affect those forces (e.g. coefficient of friction). Students can represent these forces in a free body diagram. ● Will be able to analyze action/reaction pairs. ● Can use Newton's 2nd Law to explain why equal forces do not produce equal responses. **The student exhibits no major errors or omissions.**		● Given a scenario, students can draw F.B.D. ● Can determine the net force from a force diagram and solve for any acceleration. ● Given a scenario, students can identify action-reaction pairs. ● Students can explain examples of Newton's 3rd Law in action (e.g. walking, gun recoil, etc.)
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Know definitions of different types of forces and the directions that they act. ● Can recognize examples of these forces. ● Can state Newton's 3rd Law and recognize simple examples.		● Same as above.

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand : PS2.A.2			
Topic: Momentum			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system.** ○ Students can identify the factors that affect momentum and can use those factors to calculate the amount of momentum. ○ Understand the relationship between momentum, force and time in order to predict how a given force changes momentum. **The student exhibits no major errors or omissions.**		● Students will calculate momentum of objects in a variety of situations. ● Students can describe real-world examples of how to safely change momentum using a small force over a longer time. (e.g. air bags)
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can state the definition of momentum and perform simple calculations using p = mv. ● Recognize that forces can change momentum. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Strand: PS2.A.3			
Topic: Momentum			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** ○ Students can use the Law of Conservation of Momentum to predict the outcome of collisions and explosions. **The student exhibits no major errors or omissions.**		● Students will explore the difference between elastic and inelastic collisions. ● Explore collisions with class demonstrations and online collision simulations.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students recognize that momentum will not change if no net force is exerted. (Momentum is conserved). ● Students can perform simple collision/explosion calculations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS3.A.2			
Topic: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).** ○ Students will understand the law of conservation of energy and can apply it to predict the speed, height, stretch. Mass, etc of objects as energy is converted from one form to another. ○ Students will be able to give real-world examples of energy stored in various ways. **The student exhibits no major errors or omissions.**		● Students will show transfer of energy with pie charts or other diagrams. ● Students will practice solving problems using conservation of energy. ● Students can give scenarios of energy stored in one or more ways.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students can recognize the transfer of energy from one form to another.		● Same as above

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	● Students can use the definition of each type of energy to calculate the amount of energy stored. ● Can state the Law of Conservation of Energy. ● Students can define the characteristics of systems with energy stored as, gravitational, elastic, chemical, kinetic and thermal. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand : PS3.A.1			
Topic 5: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known.** ○ Students will understand how work changes the energy in a system and can determine the amount of work done on an object. ○ Given the amount of work, students can predict the final velocity, height, etc of the system. ○ Students can recognize when a force does no work. ○ Students understand the difference between work and power and can calculate the rate at which work is done. ○ Students can describe how power affects the time needed to do work. **The student exhibits no major errors or omissions.**		● Students will give real-world examples of work done. ● Students will diagram work/energy with bar charts or other diagrams. ● Students will practice calculations. ● Students will compare real-world devices of differing power. ● Students will calculate their own power while running up stairs.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		● Same as above.

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<table>
<tr><td></td><td colspan="2">Students can recognize when work has been done.
Students can state the definition of work and use it to calculate the work done to an object.
Students can define power and calculate how much power is used to do work in simple situations.
However, the student exhibits major errors or omissions regarding the more complex ideas and processes.</td><td></td></tr>
<tr><td></td><td>1.5</td><td>Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.</td><td rowspan="4"></td></tr>
<tr><td>Score 1.0</td><td colspan="2">With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.</td></tr>
<tr><td></td><td>0.5</td><td>With help, a partial understanding of the 2.0 content, but not the 3.0 content.</td></tr>
<tr><td>Score 0.0</td><td colspan="2">Even with help, no understanding or skill demonstrated.</td></tr>
</table>

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Strand: PS3.A.3			
Topic: Work and Energy			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.** ○ Students will understand that simple machines do not decrease the amount of work, and can describe why/how they make work easier. ○ Students can calculate efficiency and mechanical advantage. **The student exhibits no major errors or omissions.**		● Students will do lab activities measuring the force needed to accomplish tasks with and without various simple machines ● Students will give examples of real-life simple machines in action.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students can identify different types of simple machines. ● Students know that S.M.'s decrease force needed by increasing distance. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Same as above.

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS2.B.2			
Topic: Electricity and Magnetism			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.** ○ Students will be able to describe electrical forces between objects. ○ Should be able to calculate the various quantities of a circuit such as resistance, current, voltage and power. ○ Will be able to use Ohm's Law to determine the current, voltage or resistance in a circuit. ○ Students will be able to explain the correlation between electricity and magnetism. **The student exhibits no major errors or omissions.**		● Be able to explain real life examples of static electricity (i.e. lightning, van der graaf generator, balloons) ● Given a schematic diagram, determine the voltage, current, resistance , and power in a parallel and series circuit. ● Calculate the voltage, resistance and current using Ohm's Law. ● Students will construct an electromagnet.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		● Identity whether a circuit is parallel or series.

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	● Students will be able to illustrate and describe the current in circuits. ● Students will be able to identify properties of the wire that will affect its ability to conduct electricity. ● Students will be able to explain the effects of magnetism. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Be able to illustrate a schematic diagram of a circuit. ● Compare the properties of the wire that make it an effective conductor. ● Know the difference between conductors and insulators. ● Students should know that like charges attract and unlike charges repel. ● Basic understanding of the structure of the atom. ● Identify magnetic material ● Understand the Earth's magnetic properties and its sources.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS1.A.3			
Topic: Thermodynamics			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.** ○ Students will be able to apply the Specific Heat Capacity equation to a substance to determine the amount of heat energy gained or lost. ○ Explain in depth how particles behave in a phase change. ○ Students can describe a scenario in which the differences between temperature and thermal energy are exhibited. ○ Students will convert between the Celsius, Fahrenheit and Kelvin scales. **The student exhibits no major errors or omissions.**		● Students will be able to apply the specific heat capacity equation. ● Students will be able to explain why evaporation is a cooling process or how particles behave during a phase change. ● Given a graph, identify the direction of energy flow and its purpose.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students will be able to compare specific heat capacities of certain substances. ● Students will be able to understand the behavior of particles before, during, or after a phase change. ● Students can define thermal energy and temperature, as well as recognize critical points on Celsius and Fahrenheit scales. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Given a data table, students can identify substances as having low or high SHC's ● If a substance has a low specific heat capacity it will undergo a faster temperature change than one with a high SHC. ● Students can explain the particle arrangement of the different states of matter. ● Be able to identify the different phase changes. ● Students are able to identify the differences between thermal energy and temperature in an everyday example.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS3.B.1			
Topic: Thermodynamics			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** ○ Students can explain the behavior of particles when they gain or lose energy. The amount of energy gained is equal to the energy lost by the other object. ○ Be able to express the amount of heat transferred between the object and find the final temperature when Heat is transferred **The student exhibits no major errors or omissions.**		● Students can solve sample problems by applying the thermal energy equation. ● Be able to use the Heat gained= heat lost equation. ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students can define the principle of thermal equilibrium. ● Students will understand how heat can be transferred and can recognize examples of the 3 methods of heat transfer.		● Students can list examples in which thermal equilibrium occurs. ● Given Illustrations of heat transfer can

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		identify which type of transfer has occurred.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: PS4.A.1			
Topic: Waves			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** ○ Students will be able to determine the speed of a wave by finding the frequency and wavelength. ○ Students should understand that frequency and wavelength are inversely proportional. ○ Be able to identify and explain factors that determine the speed of sound in a given medium. **The student exhibits no major errors or omissions.**		● Be able to find the speed, wavelength, and frequency of a wave. ● Know that the speed stays the same unless you change the medium. ● Find the wavelength or speed of a sound wave. ● Explain Doppler Effect. ● Be able to identify the overtones of a standing waves ● Find the frequency and speed from the overtone.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		● Identify the crest, trough, amplitude and wavelength, frequency, period.

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	● Students will be able to explain the characteristics and behaviors of various types of waves. ● Students will be able to identify the characteristics and behaviors of sound waves. ● Be able to identify the overtones in a standing wave. ● Students will be able to describe how sound waves interact with each other. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Identify the type of wave (transverse or compressional). ● Know the parts of a sound wave and explain the sound that is produced as a result of those characteristics. ● Know the following key terms: Reflection, refraction, diffraction, resonance, standing waves, constructive and destructive interference.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: PS4.A.2			
Topic: Waves			
Grade: 9			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other** ○ Students should understand that frequency and wavelength are inversely proportional. ○ Understands that white light is composed of all of the different colors of light. **The student exhibits no major errors or omissions.**		● Can determine the type of electromagnetic radiation based on the model provided (i.e. radio, UV, microwave, etc..) ● Knows what happens when white light is passed through a prism.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Knows the different waves that make up the electromagnetic spectrum and their properties. ● Knows that E.M. waves can travel through mediums as well as through a vacuum. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Can identify a particular wave when given its properties or uses.

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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[Biology I] ***Course Overview***	
Grade level(s): 9-12	**Credits earned:** 0.5 Credits per Semester (Full year Course)
Course Rationale	**Course Description**
Biology is a dynamic discipline. It is ever-changing and evolving. Modern students live in a society constantly faced with issues involving the principles of Biology. It is important for students to gain an insight into these Biological phenomena to make informed decisions in their daily lives.	*In this course we will approach Biological phenomena using the three dimensions (3D) noted in the Next Generation Science Standards (NGSS). The three dimensions are Science & Engineering Practices (SEP), Crosscutting Concepts (CCC), and Disciplinary Core Ideas (DCI).One part of the 3D model focuses on the disciplinary core ideas which encompasses content of broad importance or is a key organizing concept. DCIs may also include interests pertaining to your life experiences and societal or personal concerns that require scientific or technological knowledge. Much of the content you will learn in this class will build on your prior knowledge from other classes and experiences. This course will also focus on SEPs and investigations using scientific inquiry. This course focuses on CCC: patterns similarity, diversity, cause and effect, scale, proportion and quantity, systems and system models, energy and matter, structure and function, and stability and change. Some of the concepts in this class include living systems and their organization and homeostatic mechanisms, chemistry and matter, energy, ecosystems, cellular biology and protein synthesis, genetics and heredity, natural selection and evolution, and human impacts in the environment.*
Transfer Goals/Big Ideas	

- Asking Questions and Defining Problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in an argument from evidence
- Obtaining, evaluating, and communication information

Priority Missouri Learning Standards/National Standards

9-12 LS1-A-3- Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.(NGSS: HS-LS1-3)
9-12 LS1-C-1- Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. (NGSS: HS-LS1-5)
9-12 LS2-B-1- Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow. (NGSS: HS-LS2-3)
9-12 LS3-B-2-Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure (NGSS: MS-LS3-2.)
9-12 LS4-C-2-Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.(NGSS: HS-LS4-5)

Course Name:

 **Unit [1]: [Living Systems]** ***Desired Results***		
Standards	**Transfer Goal(s) /Big Ideas**	
LS 1-A-2 (NGSS- HS LS 1-2) LS 1-A-3 (NGSS- HS LS 1-3) ETAS 1-A-1 (NGSS- HS ETS 1-2) ETAS 1-B-1 (NGSS- HS ETS 1-3)	● Asking Questions and Defining Problems ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information	
	Enduring Understandings	**Essential Questions**
	● The Earth and multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. ● Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional	***1. What are the levels of organization within the Earth system?*** ***2. How do systems in living organisms interact to maintain the organism?*** ***3. How does the structure of cells relate to different functions and specialization?*** ***4. How have advances in technology influenced human health and society?***

	even as external conditions change within some range. ● Differentiation is the process of producing specialized cells within organisms, helping them to perform the essential functions of life. ● Biology and engineering combine in various ways to improve human life.	

Learning Targets
Students will… ***Use models to illustrate the relationships between components of living and nonliving systems.*** ***Use models to explain how systems within an organism interact at different levels to carry out functions necessary for life.*** ***Explain how positive and negative feedback loops help an organism to maintain homeostasis.*** ***Explain how bioengineers design and evaluate solutions to human health problems.***
Unit Duration:
3 weeks

Course Name:

<table>
<tr><td colspan="3"> 
Unit [2]: [Chemistry in Living Systems]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS1.C.3 (NGSS-HS-LS1-6)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The properties of organic and inorganic matter have the ability to control life’s processes and can be recombined in different ways to form different products.
● All biomolecules are composed of the same elements that can be assembled and disassembled to carry out life processes.</td><td>1. Why is water crucial for life on Earth?
2. What properties of water make it important to organisms?
3. How is matter changed in chemical reactions?
4. How do organisms use chemistry to survive?
5. What materials are organisms made of?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
</table>

Course Name:

Students will… *Use models to draw conclusions about properties of atoms, ions, and molecules, and the breaking and forming bonds.* *Use evidence from models to construct an explanation about how carbon can form chains and rings structures in biomolecules and how the biomolecules are used in cell processes.*
Unit Duration:
2 weeks

Course Name:

<table>
<tr><td colspan="3">Unit [3]: [Matter and Energy in Living Systems]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS1.C.1 (NGSS: HS-LS1-5)
9-12.LS1.C.2 (NGSS: HS-LS1-7)
9-12.LS2.B.1 (NGSS:HS-LS2-3)
9-12.LS2.B.2 (NGSS:HS-LS2-4)
9-12.LS2.B.3 (NGSS: HS-LS2-5)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Photosynthetic organisms convert light energy to store chemical energy.
● All organisms use cellular respiration to convert stored chemical energy into usable energy.
● There is less usable energy as energy is transferred through trophic levels.
● Matter and energy begins with producers in an ecosystem and is transferred through consumers.</td><td>1. What do plants need to survive? How do plants obtain energy?
2. How do animals obtain energy to grow?
3. How are energy and matter transferred through organisms and their environment?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
</table>

Course Name:

Students will… ***Use models to illustrate and explain how energy is transferred in the process of photosynthesis.*** ***Construct explanations about changes in matter and energy during cellular respiration.*** ***Explain, analyze, and model the flow of matter and energy through trophic level using food chain, food webs, and pyramid models.*** ***Model the flow of matter and energy through biogeochemical cycles and analyze the impacts of human activities on these cycles.***
Unit Duration:
2.5 weeks

Course Name:

<table>
<tr><td colspan="3"> 
Unit [4]: [Ecosystems: Stability and Change]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS2.A (NGSS-HS-LS2-1;NGSS-HS-LS2-2)
9-12.LS2.C .1 (NGSS-HS-LS2-6)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● 1. Ecosystems have carrying capacities, which limits the numbers of organisms and populations they can support.
● 2. These limits result from such factors as availability of living and nonliving resources and from such challenges as predation, competition, and disease.
● 3. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number</td><td>1. How do scientists measure population and changes in population?
2. What causes populations and ecosystems to remain stable or to change over time?
3. What factors affect populations within an ecosystem?
4. How do modest or drastic changes in ecosystems affect ecosystem stability?</td></tr>
</table>

	of individuals) of species in any given ecosystem.. ● 4. A complex set of intersections within an ecosystem within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. --- 1. An ecosystem can be studied by measuring size, changes, and relationships between its populations. 2. Populations remain stable or change based on various factors, biotic and abiotic, internal and external.	

Course Name:

Learning Targets
Students will… ***Use mathematical and computational representations to explain how factors affect population density, distribution, and growth patterns, and how limiting factors affect an ecosystem's carrying capacity.*** ***Use mathematical representations to analyze and explain how changes in ecosystems affect ecosystem stability.***
Unit Duration:
2 weeks

Course Name:

<table>
<tr><td colspan="3"> 
Unit [5]: [Cells: Stability and Change]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS1.B NGSS: (HS LS 1-4)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Internal and external factors/signals influence a cell’s ability to divide at different rates.
● Organisms use the process of mitosis for growth and repair.
● Differentiation produces different cell types using gene expression</td><td>1. How do organisms balance the growth and division of their cells?
2. How do organisms replace lost or damaged cells?
3. Do all cells grow and divide in the same way? At the same rate?
4. How do organisms with many cell types develop from a single cell?</td></tr>
</table>

Course Name:

Learning Targets
Students will… Use a model to illustrate the role of the cell cycle in producing and maintaining complex organisms. Use models to explain how mitosis and differentiation in cells contribute to the maintenance and reproduction of multicellular organisms.
Unit Duration:
2 weeks

Course Name:

<table>
<tr><td colspan="3"> 
Unit [6]: [The Structure and Function of DNA]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS1.A.1 (NGSS: HS-LS1-1)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The structure of DNA allows storage of genetic information.
● Genetic instructions in DNA allow for the synthesis of specific proteins.
● Gene expression is regulated in a variety of ways at different points in the cell cycle.</td><td>1. How does the structure of DNA lead to function in an organism?
2. How does the information in DNA get transferred into observable traits?
3. How is the flow of information from DNA regulated?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
</table>

Course Name:

Students will… Use evidence to evaluate claims about DNA as the molecule of inheritance and about the structure of DNA. Construct an explanation based on evidence for how the language of DNA is translated into the language of proteins. Use evidence to explain that gene expression is a regulated process that results in differentiated and specialized cells, and recognize that genes are expressed differently in prokaryotic and eukaryotic cells.
Unit Duration:
3 weeks

Course Name:

<table>
<tr><td>  </td><td colspan="2">Unit [7]: [Genetics and Heredity]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.LS3.A (NGSS-HS-LS3-1)
9-12.LS3.B.3 (NGSS- HS-LS3-2)
9-12.LS3.B.4 (NGSS- HS-LS3-3)
9-12.ETS1.B.1 (NGSS- HS-ETS1-3)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Genetically varied gametes from each parent randomly combine during fertilization to provide unique traits in the offspring. (DNA in each parent’s gamete combines during fertilization to determine offspring genetic makeup)
● Meiosis and sexual reproduction create new genetic combinations that contribute to genetic variation among generations.
● Random mutation can introduce new genes into an organism/species.</td><td>1. How are traits passed from parents to offspring?
2. Why do the offspring of two parents all look different from each other?
3. How does diversity in traits arise over generations?
4. How can we determine the probability that an organism's expressed version of a trait will be passed to its offspring?</td></tr>
</table>

	● *An organism's genetics can be manipulated and combined with DNA from other organisms to create desired traits.*	**5. Can scientists alter the genetic material of other organisms? How might humans use this ability?**
Learning Targets		
Observe patterns and use models to explain how meiosis produces genetically unique cells and use evidence to make claims about genetic variation. *Ask questions about the role of genes and the environment in coding for traits that are passed down from parents to offspring.* *Construct explanations about how traits are passed from parents to offspring.* *Explain how mutations can increase genetic diversity.* *Ask questions and explore benefits and risks of genetic testing, cloning, and genetic engineering.*		
Unit Duration:		
3.5 weeks		

Course Name:

<table>
<tr><th colspan="3"> 
Unit [8]: [Evidence for Evolution]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS4.A.1 (NGSS: HS-LS4-1)
9-12.LS4.B.1 (NGSS: HS-LS4-2)
9-12.LS4.B.2 (NGSS: HS-LS4-3)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Through the use of the fossil record, comparative anatomy, embryology, and DNA sequences, scientists have evidence to represent how life has changed over time.
● Organisms with traits that are more favorable to their environment, survive and reproduce at a greater rate than others.</td><td>1. How do we know living things have changed over time?
2. What are the mechanisms of natural selection, and how do they lead to changes in species over time?
3. How can environmental changes impact traits in a population?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Construct explanations about the evidence that supports common ancestry and evolution of living organisms.* *Construct an explanation based on evidence for how natural selection leads to changes in populations.*
Unit Duration:
2 weeks

Course Name:

<table>
<tr><td colspan="3">Unit [9]: [Patterns of Evolution]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="2">9-12.LS4.C.1 (NGSS: 9-12 LS 4-4)
9-12.LS4.C.2 (NGSS: 9-12 LS 4-5)
9-12.LS3.B.4 (NGSS: 9-12 LS 3-3)
(NGSS: 9-12 LS 2-8)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● When enough anatomical, behavioral, or physiological variation develops between different groups in a species, then a new species may result.
● A species will go extinct if it can not evolve to survive in a changing environment.
● Evolution can follow different patterns such as convergent, divergent, and coevolution.</td><td>1. How does evolution lead to new species?
2. What causes the extinction of some species?
3. What are some of the patterns we see in evolution?
4. Can behaviors be inherited?</td></tr>
</table>

Course Name:

Learning Targets
Students will… Objective: Explain the different mechanisms that cause populations to evolve Objective: Explore how changes in environmental conditions can lead to the emergence, expansion, or extinction of species. Objective: Construct explanation about the evolution and group behavior
Unit Duration:
2.5 weeks

Course Name:

<table>
<tr><th colspan="3"> 
Unit [10]: [Human Impacts on the Environment]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS2.A (NGSS: HS-LS2-1)
9-12.LS2.C.2 (NGSS: HS-LS2-7)
9-12.LS4.C.3 (NGSS:9-12.LS4.C.3)
9-12.ETS1.A.1 (NGSS: HS-ETS1-1)
9-12.ETS1.A.2 (NGSS: HS-ETS1-2)</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Anthropogenic changes in the environment can disrupt an ecosystem and threaten the survival of some species.
● Human activity has the ability to find solutions in order to reverse negative impacts in an effort to increase biodiversity.
● Solutions need to take into account constraints like cost, safety, reliability and aesthetics while considering social, cultural, and environmental impacts.</td><td>1. How does human population growth affect the environment?
2. How can humans mitigate the effects of human development on biodiversity?
3. Why do solutions to environmental impacts need to consider a range of criteria, including societal needs?</td></tr>
</table>

Course Name:

Learning Targets
Students will… Objective: Students design, evaluate, and refine a solution for reducing the impacts of human population growth on the environment and biodiversity. Objective: Students consider the impacts of habitat loss, introduction of invasive species, and over harvesting on biodiversity. Objective: Students explore the concept of engineering solutions to environmental problems.
Unit Duration:
2.5 weeks

Standard: LS 1-A-2			
Topic: Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms and apply it to a real world situation.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: LS 1-A-3			
Topic: Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: ETAS 1-A-1			
Topic: Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: ETAS 1-B-1			
Topic: Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: LS1.C.3			
Topic: Chemistry in Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules and apply it to real world situations. Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules.[Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules.[Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS1.C.1*			
Topic: Matter and Energy in Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy and apply it to real life situations.. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Standard: *LS1.C.2*			
Topic: Matter and Energy and Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy and apply it to real world situations. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS1.B.1*			
Topic: Matter and Energy and Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. and apply it to real world situations. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS2.B.2*			
Topic: Matter and Energy and Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem and apply it to real world situations. [Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one tropic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem. [Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one tropic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem. [Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one tropic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Standard: *LS2.B.3*			
Topic: Matter and Energy and Living Systems			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere and apply it to real world situations. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *9-12.LS2.A*			
Topic: Ecosystems: Stability and Change; Human Impacts on the Environment			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations and apply it to real world situations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *9-12.LS2.C .1*			
Topic: Ecosystems: Stability and Change			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** *Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics and apply it to real world situations. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]*		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** *Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]* **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** *Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]* **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.B			
Topic: Cells: Stability and Change			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms and apply it to real world situations. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Standard: .LS1.A.1			
Topic: The Structure and Function of DNA			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells and apply it to real world situations.[Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS3.A*			
Topic: Genetics and Heredity			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS3.B.3*			
Topic: Genetics and Heredity			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors, and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS3.B.4*			
Topic: Genetics and Heredity; Patterns of Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *ETS1.B.1*			
Topic: Genetics and Heredity			
Grade:			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: LS4.A.1			
Topic: Evidence for Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.) **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean written report, oral discussion, etc.)		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS4.B.1*			
Topic: Evidence for Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation o individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation o individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.) **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation o individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS4.B.2*			
Topic: Evidence for Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: LS4.C.1			
Topic: Patterns of Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct an explanation based on evidence for how natural selection leads to adaptation of populations Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems and apply it to real world situations. (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution		

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	of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: LS4.C.2			
Topic: Patterns of Evolution			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers,		

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	droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: LS3.B.4			
Topic: Patterns of Evolution; Genetics and Heredity			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.]		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS2.A*			
Topic: Unit 10- Human Impacts on the Environment; Ecosystems: Stability and Change			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations and apply it to real world situations.		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples		

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	of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

Standard: *LS2.C.2*			
Topic: Unit 10- Human Impact on the Environment			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement: Examples of solutions may include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, agriculture and mining programs, and ecotourism.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement: Examples of solutions may include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, agriculture and mining programs, and ecotourism.]		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *LS4.C.3*			
Topic: Unit 10- Human Impacts on the Environment			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *ETS1.A.1*			
Topic: Unit 10- Human Impacts on the Environment			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants and apply it to a real world situation.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: *ETS1.A.2*			
Topic: Unit 10-Human Impacts on the Environment			
Grade: 9-10			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering and apply it to real world situations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
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General Chemistry ***Chemistry is the study of matter and the transformation it undergoes.***	
Grade level(s): 10-12	**Credits earned:** 0.5 credits per semester
Course Rationale	**Course Description**
This chemistry course provides students with a foundation in the understanding of matter and its transformations.	*Chemistry is the study of matter and the transformations that it undergoes. Topics include atomic theory, the periodic table, chemical reactions, and nuclear chemistry. Emphasis is on problem solving and applying the scientific method.*
Transfer Goals/Big Ideas	
● **Asking Questions and Defining Problems** ● **Developing and using models** ● **Planning and carrying out investigations** ● **Analyzing and interpreting data** ● **Using mathematics and computational thinking** ● **Constructing explanations and designing solutions** ● **Engaging in an argument from evidence** ● **Obtaining, evaluating, and communication information**	

Priority Missouri Learning Standards/National Standards
● **9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]** ● **9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]** ● **9-12.PS1.A.2 Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, or of oxygen and hydrogen.]** ● **9-12.PS1.A.3 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]** ● **9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on conservation of matter and mass through balanced chemical equations, use of the mole concept and proportional relationships.]** ● **9-12.PS1.A.4 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).**

<table>
<tr><th colspan="3">Unit 1: Laboratory Safety
Proper Experimental Procedure</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">9-12.PS1.A.4</td><td colspan="2">BIG IDEA 4: SCIENCE PRACTICES
As a science, chemistry requires experimentation to collect viable data that can support or refute scientific claims. All experimentation must be done in a valid, safe way to preserve the integrity of the data as well as to protect the health of the scientist. Experimental data is the cornerstone to scientific theories and hypotheses as it provides evidence for scientific claims.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select safe, appropriate investigative methods in order to obtain evidence relevant to the explanation.
Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)</td><td>How do scientists approach solving problems?
How can an experiment be conducted in a safe, controlled environment?
Where are and how do you operate the laboratory safety equipment?
How do you properly use lab equipment?
What is/are the proper responses to a laboratory emergency?</td></tr>
</table>

Learning Targets
Students will… **Design and conduct a valid experiment.** **Manipulate laboratory equipment safely.** **Measure accurately in the metric system.**
Unit Duration:
1 week

<table>
<tr><th colspan="3">Unit 2: Principles of Chemistry
Introduction to Matter</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.A.4</td><td colspan="2">BIG IDEA 3: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Properties of a substance can change with alterations to its atomic/molecular structure
● Substances can be changed on a macroscopic level that will not alter its chemical properties
● Substances have properties that can be used to describe and classify them
● While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary</td><td>● How are the properties of matter defined by its classification?
● How does the atomic/molecular arrangement dictate the state of a substance?
● How do energy changes affect the macroscopic and particle states of a substance?
● What does a chemical formula tell us about a compound?</td></tr>
</table>

Learning Targets
Students will… ● **Classify substances as elements, compounds or mixtures.** ● **Distinguish between different states of matter at the macro and particle levels.** ● **Distinguish between physical and chemical changes.** ● **Use chemical and physical properties to identify an unknown substance.** ● **Separate a mixture into its component substances.** ● **Interpret a phase change diagram.**
Unit Duration:
3 - 4 weeks

<table>
<tr><th colspan="3"> 
Unit 3: Atomic Structure
The Atom and The Parts That Are Contained Within</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">9-12.PS1.A.4
9-12.PS1.C.1</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>Elements are made up of atoms that are composed of smaller particles.
A Coulombic force exists between charged particles.
Transmutations can occur by changing an atom’s nucleus.
There are multiple types of radioactive decay.
The rate of decay for a nucleus is represented by its half-life.</td><td>What is the structure of an atom?
What gives an element its properties?
How can nuclei of the same element differ?
What happens when a nucleus changes?
What happens when an atom gains or loses electrons?
How is the Coulombic force between charged particles influenced by distance between the charged particles and the magnitude of charge?
How does an atom change if the composition of the nucleus is altered?
How are nuclear reactions balanced?
How is half-life calculated?</td></tr>
</table>

Learning Targets
Students will… ● **Describe the atom as having a dense, positive nucleus surrounded by a cloud of negative electrons.** ● **Determine the number of protons, electrons and neutrons in a particular isotope.** ● **Know the charge and relative masses of each subatomic particle.** ● **Know that mass numbers must be whole numbers but atomic mass may be decimal.** ● **Know that atomic number determines the identity of the atom.** ● **Qualitatively use Coulomb's Law to describe the attractive/repulsive forces between charged particles.** ● **Be able to balance a nuclear decay reaction for alpha and beta decay.** ● **Be able to calculate the half-life of a chemical species.**
Unit Duration:
4 weeks

<table>
<tr><th colspan="3">Unit 4: Periodic Table
Understanding the Periodic Table and the Patterns Within</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.A.1</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The organization of the periodic table is based on the properties of the elements
● Patterns in the periodic table can be found to describe the relative size of an atom or ion as well as the reactivity of an atom or ion</td><td>● How does the structure of the periodic table allow us to predict the chemical and physical properties of an element?
● How does electron arrangement determine bonding?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to describe how the valence electron configuration determines how atoms interact and may bond.** ● **Be able to describe the chemical and physical properties of an element based on its position on the periodic table.** ● **Be able to draw a Lewis dot structure for elements and ions.**
Unit Duration:
3-4 Weeks

Unit 5: Ionic Bonds
Ionic Bonding and Replacement Reactions

Standards	Transfer Goal(s) /Big Ideas
● **9-12.PS1.A.3** ● **9-12.PS1.B.3**	**BIG IDEA 2: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.** **BIG IDEA 3: TRANSFORMATIONS** **At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.**

Enduring Understandings	Essential Questions
● **The type of bonding affects the properties of a compound.** ● **The type of bond determines its nomenclature.** ● **Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.**	● **How does electron arrangement determine bonding?** ● **How are compounds named?** ● **How is the formula for an ionic compound determined?** ● **How does the law of conservation of mass relate to balancing equations?**

Learning Targets
Students will… **Students will be able to describe how the valence electron configuration determines how atoms interact and may bond.** **Students will be able to compare and contrast ionic, covalent and metallic bonding.** **Students will be able to write the formula and name ionic compounds.** **Students will be able to write a chemical equation as a chemist's shorthand method of describing a chemical change.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 6: Covalent Bonds
Covalent Bonding, Molecular Structures and Redox Reactions</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">

- **9-12.PS1.A.3**
- **9-12.PS1.B.3**

</td><td colspan="2">

BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.

BIG IDEA 3: TRANSFORMATIONS
At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.

</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>

- **The type of bond determines its nomenclature.**
- **Molecular formulas show the number of each type of atom in a molecule**
- **Molecules have particular shapes depending on number of atoms and electron domains**

</td><td>

- **How are compounds named?**
- **How is the structure for a covalent compound determined?**
- **How do electron domains affect the molecule's shape?**
- **How does the law of conservation of mass relate to balancing equations?**

</td></tr>
</table>

	● **Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.**	● **How do scientists determine the molecular formula of a compound?**
Learning Targets		
Students will… ● **Be able to name a covalent compound correctly.** ● **Be able to draw the Lewis structure for a covalent compound.** ● **Be able to recognize linear, bent, pyramidal and tetrahedral molecular shapes.** ● **Be able to determine the molecular formula of a compound.**		
Unit Duration:		
2-3 Weeks		

<table>
<tr><th colspan="3">Unit 7: The Mole
Mole Conversions</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The mole is used to represent a large collection of particles.
● Quantities of a substance can be expressed in terms of moles, mass, volume, and number of particles.
● Mass and atoms must be conserved in a chemical reaction.</td><td>● How do scientists represent very large or small chemical quantities?
● How do scientists calculate the mass or volume of a substance?
● How does the law of conservation of mass relate to balancing equations?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to use atomic mass to calculate the molar mass of a substance.** ● **Be able to calculate the number of moles, the amount of mass or volume, and the number of particles in a substance.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 8: Stoichiometry
Stoichiometry</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● A balanced chemical equation is necessary to relate quantities of reactants and products.
● Reactants and products in a chemical reaction are quantitatively related by the mole.
● The amount of product recovered is determined by the limiting reactant.
● Numerous factors influence the percent yield of a chemical reaction.</td><td>● How are quantities of reactants and products related?
● What factor(s) influence the actual yield?
● How is the theoretical yield of a chemical reaction calculated?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to use a balanced chemical equation to describe the mole ratio between reactants and products.** ● **Be able to calculate the theoretical yield of a product or calculate the amount of reactant needed to produce a given theoretical yield for a chemical reaction.** ● **Be able to calculate the percent yield of a chemical reaction.** ● **Be able to determine the limiting reactant in a chemical reaction.**
Unit Duration:
3-4 weeks

<table>
<tr><th colspan="3">Unit 9: Gas Laws
KMT and Gas Laws</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>Kinetic molecular theory can be used to explain the difference in properties of solids, liquids and gases.
Gas behavior can be quantitatively described using pressure, temperature, volume and mole relationships.</td><td>How is the physical state of matter related to the particle behavior of a substance?
What are the major tenets of kinetic molecular theory?
Under what conditions do real gases behave like ideal gases?
How does the behavior of gas particles change with alterations to pressure, volume, temperature and mole amounts?</td></tr>
</table>

Learning Targets
Students will… ● **Use the kinetic molecular theory to explain the difference in properties and structure of solids, liquids and gases.** ● **Use pressure, temperature, volume and number of moles to quantitatively describe a gas.** ● **Be able to relate the molar quantities of gases with stoichiometry .** ● **Be able to contrast the properties of real and ideal gases.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 10: Solution Chemistry
Solutions, Acids and Bases</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">-9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.

BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>Solutions can be described in both qualitative and quantitative terms.
Solutions can be classified as acidic or basic based upon the concentration of hydrogen and hydroxide ions present.</td><td>How are solutions differentiated from other types of mixtures?
What properties define an acid or a base?
How are indicators used to identify a solution as an acid or base?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to qualitatively and quantitatively describe a solution.** ● **Identify a solution as acidic or basic based upon the pH of the solution.** ● **Calculate the pH of a solution given the concentration of the hydrogen ions in solution.**
Unit Duration:
2-3 Weeks

Strand 1: 9-12.PS1.A.1			
Topic: Periodic Table and Element Properties			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the charges of the ions formed by an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for monatomic ions. ● Will be able to determine the composition and electron configuration of an atom. ● Is able to explain the underlying causes of the regular and repeating patterns of chemical and physical properties within the periodic table **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to identify the number of subatomic particles in an atom given its atomic and mass number. ● Be able to identify the subatomic particles of an atom and their location. ● Is able to identify the atomic structure of an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for single atoms. ● Is able to recognize the regular and repeating pattern of chemical and physical properties within the periodic table. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 2: 9-12.PS1.A.2			
Topic: Bonding and Chemical Reactions			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Recognizes how valence electrons are used in bonding. ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to predict based on reactivity of the reactants and states of the products if a reaction will occur in the forward direction. ● Is able to write a net ionic equation. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to predict the products of chemical reactions. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 3: 9-12.PS1.A.3			
Topic: Bonding and Intermolecular Forces			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to draw molecular structures that may include single or multiple bonds using Lewis Dot Structures. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to draw molecular structures that include single Lewis Dot Structures. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 4: 9-12.PS1.B.3			
Topic: Chemical Quantities			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** ● **Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Is able to convert between moles and grams, liters and particles. ● Is able to write and balance chemical equations ● Is able to use a balanced chemical equation to derive quantitative relationships involved in a chemical change. ● Is able to calculate theoretical yield, actual yield and percent yield given the appropriate information. ● Be able to relate the molar quantities of gases with stoichiometry **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to calculate the molar mass of a compound. ● Is able to understand the concept of conservation of mass as related to the balancing of chemical equations. ● Understands that coefficients in a balanced chemical equation show a molar relationship between products and reactants.		

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	● Is able to differentiate between theoretical yield, actual yield and percent yield. ● Use pressure, temperature, volume and number of moles to quantitatively describe a gas. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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<table>
<tr><th colspan="4">Strand 5: 9-12.PS1.A.4</th></tr>
<tr><th colspan="4">Topic: Experimental Design</th></tr>
<tr><th colspan="4">Grade: 11</th></tr>
<tr><td>Score 4.0</td><td colspan="2">In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.</td><td>Sample Activities
● Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.</td></tr>
<tr><td></td><td>3.5</td><td>In addition to score 3.0 performance, in-depth inferences and applications with partial success.</td><td></td></tr>
<tr><td>Score 3.0</td><td colspan="2">The student:
● Recognize the difference between accuracy and precision.
● Is able to recognize and explain sources of error in a scientific experiment.
● Is able to plan and safely conduct a valid, scientific experiment.
● Demonstrates sound knowledge of lab procedures.
● Uses safe laboratory practices independently.
The student exhibits no major errors or omissions.</td><td></td></tr>
<tr><td></td><td>2.5</td><td>No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.</td><td></td></tr>
<tr><td>Score 2.0</td><td colspan="2">There are no major errors or omissions regarding the simpler details and processes as the student:
● Performs basic processes, such as: measure length, mass, volume and temperature
● Recognizes or recalls specific terminology such as: base units of</td><td></td></tr>
</table>

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	measurement, metric prefixes, measurement tools, significant figures, percent error. ● Works to follow each step before moving on to the next step ● Work is organized using appropriate units and labels. ● Is able to communicate experimental results in graphical and tabular form. ● Is able to correctly identify and use lab equipment. ● Follows lab safety guidelines. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 5: 9-12.PS1.A.4			
Topic: Nuclear Chemistry			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** ● **9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to balance nuclear equations for alpha and beta decay. ● Will understand half-life concepts and be able to solve half-life problems. ● WIl be able to compare and contrast the difference between fission and fusion **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	● Recognizes or recalls specific terminology such as: nuclear decay, alpha decay, beta decay, gamma radiation, half-life, fission, fusion ● Will be able to explain the benefits and risks of radioactivity. ● WIl be able to define fission and fusion **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Honors Chemistry ***Chemistry is the study of matter and the transformation it undergoes.***	
Grade level(s): 10-11	**Credits earned:** 0.5 credits per semester
Course Rationale	**Course Description**
This chemistry course provides students with a foundation in the understanding of matter and its transformations.	*Chemistry is the study of matter and the transformations that it undergoes. Topics include atomic theory, the periodic table, chemical reactions, VSEPR theory, gas laws and solutions. Emphasis is on problem solving and applying the scientific method.*
Transfer Goals/Big Ideas	
● **Asking Questions and Defining Problems** ● **Developing and using models** ● **Planning and carrying out investigations** ● **Analyzing and interpreting data** ● **Using mathematics and computational thinking** ● **Constructing explanations and designing solutions** ● **Engaging in an argument from evidence** ● **Obtaining, evaluating, and communication information**	
Priority Missouri Learning Standards/National Standards	
● **9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** ● **9-12.PS1.A.2 Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.**	

- **9-12.PS1.A.3 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers.**
- **9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**
- **9-12.PS1.A.4 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.**

<table>
<tr><th colspan="3">Unit 1: Laboratory Safety
Proper Experimental Procedure</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.A.4</td><td colspan="2">BIG IDEA 4: SCIENCE PRACTICES
As a science, chemistry requires experimentation to collect viable data that can support or refute scientific claims. All experimentation must be done in a valid, safe way to preserve the integrity of the data as well as to protect the health of the scientist. Experimental data is the cornerstone to scientific theories and hypotheses as it provides evidence for scientific claims.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select safe, appropriate investigative methods in order to obtain evidence relevant to the explanation.
● Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
● Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)</td><td>1. How do scientists approach solving problems?
2. How can an experiment be conducted in a safe, controlled environment?
3. Where are and how do you operate the laboratory safety equipment?
4. How do you properly use lab equipment?
5. What is/are the proper responses to a laboratory emergency?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
Design and conduct a valid experiment.
Manipulate laboratory equipment safely.
Measure accurately in the metric system.</td></tr>
</table>

Unit Duration:
1 week

<table>
<tr><th colspan="3">Unit 2: Principles of Chemistry
Introduction to Matter</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.A.4</td><td colspan="2">BIG IDEA 3: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Properties of a substance can change with alterations to its atomic/molecular structure
● Substances can be changed on a macroscopic level that will not alter its chemical properties
● Substances have properties that can be used to describe and classify them
● While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary</td><td>1. How are the properties of matter defined by its classification?
2. How does the atomic/molecular arrangement dictate the state of a substance?
3. How do energy changes affect the macroscopic and particle states of a substance?
4. What does a chemical formula tell us about a compound?</td></tr>
</table>

Learning Targets
Students will… ● **Classify substances as elements, compounds or mixtures.** ● **Distinguish between different states of matter at the macro and particle levels.** ● **Distinguish between physical and chemical changes.** ● **Use chemical and physical properties to identify an unknown substance.** ● **Separate a mixture into its component substances.** ● **Interpret a phase change diagram.**
Unit Duration:
3 - 4 weeks

<table>
<tr><th colspan="3"> 
Unit 3: Atomic Structure
The Atom and The Parts That Are Contained Within</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.A.4</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Elements are made up of atoms that are composed of smaller particles.
● A Coulombic force exists between charged particles.
● The chemical properties of an atom are mainly determined by its electron configuration.</td><td>1. What is the structure of an atom?
2. How do subatomic particles determine the properties of elements?
3. How is the Coulombic force between charged particles influenced by distance between the charged particles and the magnitude of charge?</td></tr>
</table>

Learning Targets
Students will… ● **Describe the atom as having a dense, positive nucleus surrounded by a cloud of negative electrons.** ● **Determine the number of protons, electrons and neutrons in a particular isotope.** ● **Know the charge and relative masses of each subatomic particle.** ● **Know that mass numbers must be whole numbers but atomic mass may be decimal.** ● **Know that atomic number determines the identity of the atom.** ● **Qualitatively use Coulomb's Law to describe the attractive/repulsive forces between charged particles.** ● **Be able to write electron configurations for atoms and ions.** ● **Be able to construct an atom/ion's orbital diagram.**
Unit Duration:
3-4 weeks

<table>
<tr><th colspan="3">Unit 4: Periodic Table
Understanding the Periodic Table and the Patterns Within</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● 9-12.PS1.A.1</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The organization of the periodic table is based on the properties of the elements
● Patterns in the periodic table can be found to describe the relative size of an atom or ion as well as the reactivity of an atom or ion</td><td>1. How does the structure of the periodic table allow us to predict the chemical and physical properties of an element?
2. How does electron arrangement determine bonding?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Be able to describe how the valence electron configuration determines how atoms interact and may bond.
● Be able to describe the chemical and physical properties of an element based on its position on the periodic table.
● Be able to draw a Lewis dot structure for elements and ions.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">3-4 Weeks</td></tr>
</table>

<table>
<tr><td colspan="3"> 
Unit 5: Ionic Bonds
Ionic Bonding and Replacement Reactions</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● 9-12.PS1.A.3
● 9-12.PS1.A.2
● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.
BIG IDEA 3: TRANSFORMATIONS
At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The type of bonding affects the properties of a compound.
● The type of bond determines its nomenclature.
● Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.
● Products of a replacement reaction vary depending on reactant reactivity and product state.</td><td>1. How does electron arrangement determine bonding?
2. How are compounds named?
3. How is the formula for an ionic compound determined?
4. How does the law of conservation of mass relate to balancing equations?
5. How does the reactivity of metals and the state of the products affect the ability of a reaction to proceed forward?</td></tr>
</table>

Learning Targets
Students will… **Students will be able to describe how the valence electron configuration determines how atoms interact and may bond.** **Students will be able to compare and contrast ionic, covalent and metallic bonding.** **Students will be able to write the formula and name ionic compounds.** **Students will be able to write a chemical equation as a chemist's shorthand method of describing a chemical change.** **Students will be able to predict the products of a single or double replacement reaction.** **Students will be able to predict the solubility of a compound.** **Students will be able to write a net ionic equation.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 6: Covalent Bonds
Covalent Bonding, Molecular Structures and Redox Reactions</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.A.3
● 9-12.PS1.A.2
● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.
BIG IDEA 3: TRANSFORMATIONS
At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The type of bond determines its nomenclature.
● Molecules have particular shapes depending on number of atoms and electron domains
● The shape and symmetry of a molecule affects its intermolecular forces
● Intermolecular forces determine macroscopic properties of a molecule
● Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.
.</td><td>6. How are compounds named?
7. How is the structure for a covalent compound determined?
8. How does the electronegativity difference affect bond polarity?
9. How does the shape and bond polarity influence a molecule’s polarity?
10. How do intermolecular forces determine the properties of a substance?
11. How does the law of conservation of mass relate to balancing equations?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to name a covalent compound correctly.** ● **Be able to draw the Lewis structure for a covalent compound** ● **Be able to recognize linear, bent, pyramidal and tetrahedral molecular shapes** ● **Be able to determine bond and molecular polarity** ● **Be able to identify which intermolecular force(s) occur between particles of a substance** ● **Be able to predict the effect of intermolecular forces on the properties of a substance**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 7: The Mole
Mole Conversions</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The mole is used to represent a large collection of particles.
● Quantities of a substance can be expressed in terms of moles, mass, volume, and number of particles.
● Empirical formulas show the simplest whole-number ratio of atoms in a compound.
● Molecular formulas show the number of each type of atom in a molecule.
● Mass and atoms must be conserved in a chemical reaction.</td><td>● How do scientists represent very large or small chemical quantities?
● How do scientists calculate the mass or volume of a substance?
● How do scientists determine the empirical and molecular formula of a compound?
● How does the law of conservation of mass relate to balancing equations?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to use atomic mass to calculate the molar mass of a substance.** ● **Be able to calculate the number of moles, the amount of mass or volume, and the number of particles in a substance.** ● **Be able to determine the empirical and molecular formula of a compound.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 8: Stoichiometry
Stoichiometry</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● A balanced chemical equation is necessary to relate quantities of reactants and products.
● Reactants and products in a chemical reaction are quantitatively related by the mole.
● The amount of product recovered is determined by the limiting reactant.
● Numerous factors influence the percent yield of a chemical reaction.</td><td>● How are quantities of reactants and products related?
● What factor(s) influence the actual yield?
● How is the theoretical yield of a chemical reaction calculated?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
● Be able to use a balanced chemical equation to describe the mole ratio between reactants and products.
● Be able to calculate the theoretical yield of a product or calculate the amount of reactant needed to produce a given theoretical yield for a chemical reaction.
● Be able to calculate the percent yield of a chemical reaction.
● Be able to determine the limiting and excess reactant in a chemical reaction.</td></tr>
</table>

Unit Duration:
3-4 weeks



Unit 9: Gas Laws
KMT and Gas Laws

Standards	**Transfer Goal(s) /Big Ideas**	
● **9-12.PS1.B.3** ● **9-12.PS1.A.4**	**BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY** **Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.**	
	Enduring Understandings	**Essential Questions**
	● **Kinetic molecular theory can be used to explain the difference in properties of solids, liquids and gases.** ● **Gas behavior can be quantitatively described using pressure, temperature, volume and mole relationships.**	● **How is the physical state of matter related to the particle behavior of a substance?** ● **What are the major tenets of kinetic molecular theory?** ● **Under what conditions do real gases behave like ideal gases?** ● **How does the behavior of gas particles change with alterations to pressure, volume, temperature and mole amounts?**

Learning Targets
Students will… ● **Use the kinetic molecular theory to explain the difference in properties and structure of solids, liquids and gases.** ● **Use pressure, temperature, volume and number of moles to quantitatively describe a gas.** ● **Be able to relate the molar quantities of gases with stoichiometry .** ● **Be able to contrast the properties of real and ideal gases.**
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 10: Solution Chemistry
Solutions, Acids and Bases</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.
BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><td>Enduring Understandings
● Solutions can be described in both qualitative and quantitative terms.
● Solution formation is a function of the attraction between the solvent and solute particles.
● Solutions can be classified as acidic or basic based upon the concentration of hydrogen and hydroxide ions present.</td><td>Essential Questions
● How are solutions differentiated from other types of mixtures?
● How does solution formation occur?
● How does the quantity of moles in a solution affect concentration?
● What properties define an acid or a base?
● How are indicators used to identify a solution as an acid or base?</td></tr>
</table>

Learning Targets
Students will… ● **Be able to qualitatively and quantitatively describe a solution.** ● **Be able to calculate the molarity and mole fraction of a solution.** ● **Use dilution calculations to make a solution of specific molarity from a stock solution.** ● **Identify a solution as acidic or basic based upon the pH of the solution.** ● **Calculate the pH of a solution given the concentration of the hydrogen ions in solution.**
Unit Duration:
3-4 Weeks

Strand 1: 9-12.PS1.A.1			
Topic: Periodic Table and Element Properties			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the charges of the ions formed by an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for monatomic ions. ● Will be able to determine the composition and electron configuration of an atom. ● Is able to explain the underlying causes of the regular and repeating patterns of chemical and physical properties within the periodic table. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to identify the number of subatomic particles in an atom given its atomic and mass number. ● Be able to identify the subatomic particles of an atom and their location. ● Is able to identify the atomic structure of an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for single atoms. ● Is able to recognize the regular and repeating pattern of chemical and physical properties within the periodic table. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 2: 9-12.PS1.A.2			
Topic: Bonding and Chemical Reactions			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Recognizes how valence electrons are used in bonding. ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to predict based on reactivity of the reactants and states of the products if a reaction will occur in the forward direction. ● Is able to write a net ionic equation. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to predict the products of chemical reactions. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 3: 9-12.PS1.A.3			
Topic: Bonding and Intermolecular Forces			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to predict a molecule's three-dimensional geometry. ● Is able to draw molecular structures that may include single or multiple bonds using Lewis Dot Structures. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to draw molecular structures that include single Lewis Dot Structures. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 4: 9-12.PS1.B.3			
Topic: Chemical Quantities			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Is able to convert between moles and grams, liters and particles. ● Is able to use percent composition to determine the empirical and molecular formulas of a compound. ● Is able to write and balance chemical equations ● Is able to use a balanced chemical equation to derive quantitative relationships involved in a chemical change. ● Is able to calculate theoretical yield, actual yield and percent yield given the appropriate information. ● Be able to relate the molar quantities of gases with stoichiometry ● Is able to solve a dilution problem. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to calculate the molar mass of a compound. ● Is able to calculate the percent composition of a compound. ● Is able to understand the concept of conservation of mass as related to the balancing of chemical equations. ● Understands that coefficients in a balanced chemical equation show a molar relationship between products and reactants. ● Is able to differentiate between theoretical yield, actual yield and percent yield. ● Is able to solve for the molarity of a solution		

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	● Use pressure, temperature, volume and number of moles to quantitatively describe a gas. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 5: 9-12.PS1.A.4			
Topic: Experimental Design			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Recognize the difference between accuracy and precision. ● Is able to record measurements to the correct number of significant digits. ● Is able to recognize and explain sources of error in a scientific experiment. ● Is able to plan and safely conduct a valid, scientific experiment. ● Demonstrates sound knowledge of lab procedures. ● Uses safe laboratory practices independently. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Performs basic processes, such as: measure length, mass, volume and temperature ● Recognizes or recalls specific terminology such as: base units of measurement, metric prefixes, measurement tools, significant figures, percent error. ● Works to follow each step before moving on to the next step ● Work is organized using appropriate units and labels. ● Is able to communicate experimental results in graphical and tabular form. ● Is able to correctly identify and use lab equipment. ● Follows lab safety guidelines.		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand 5: 9-12.PS1.A.4			
Topic: Physical Properties			
Grade: 10-11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Be able to predict the effect of intermolecular forces on the properties of a substance ● Is able to quantify the relationship between pressure, volume, temperature and amount of gas. ● Is able to explain vapor pressure and phase changes as a function of particle motion and temperature. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Be able to identify which intermolecular force(s) occur between particles of a substance ● Understands the relationships between pressure, volume, temperature and amount of gas.		

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	● Will be able to describe solids, liquids and gases in terms of particle motion that depends upon temperature. ● Be able to contrast the properties of real and ideal gases. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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[Biology II- Human Biology] *Course Overview*	
Grade level(s): 11-12	**Credits earned:** 0.5 per semester
Course Rationale	**Course Description**
The human biology class is an elective class designed for students interested in medically related fields or who are interested in extending their practical knowledge about the body in which they live. Through the study of the human body, students develop an understanding of who they are, what makes their bodies work, and what happens when their bodies malfunction.	This laboratory course is for serious students with average or better ability who are interested in learning about the various parts of the human body and their functions. Dissections of animal specimens will also be explored in order to help relate their organs to the organs of the human body.
Transfer Goals/Big Ideas	
● **Asking Questions and Defining Problems** ● **Developing and using models** ● **Planning and carrying out investigations** ● **Analyzing and interpreting data** ● **Using mathematics and computational thinking** ● **Constructing explanations and designing solutions** ● **Engaging in an argument from evidence** ● **Obtaining, evaluating, and communication information**	

Priority Missouri Learning Standards/National Standards
9-12.LS1.A.1 -Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] ***9-12.LS1.A.2 -Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.]*** ***9-12.LS1.A.3 -Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.]*** ***9-12.LS1.C.2 -Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]*** ***9-12.LS1.C.3 -Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]***

Course Name:

<table>
<tr><th colspan="3"> 
Unit [1]: [Anatomical Terminology]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Proper anatomical terminology is required for accurate and universal communication.
● Living things can be described, organized and classified based on levels of structural organization.</td><td>1. What does it mean to be human?
2. How can you describe a human in terms of directionality?
3. How can you relate the anatomical position to cavities, planes, and movements?
4. Can you identify different levels of cellular organization?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Explain how anatomy and physiology are related.* *List the levels of organization in the human body and the characteristics of each.* *Identify the locations of the major body cavities.* *List the organs located in each major body cavity.* *Properly use the terms that describe relative positions, body sections, and body regions.*
Unit Duration:
2 weeks

Course Name:

<table>
<tr><th colspan="3">Unit [2]: [Cytology]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.1
9-12.LS1.A.3</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Living things can be described, organized and classified based on levels of structural organization.
● Living things depend on maintaining homeostasis and necessary life functions.
● The cellular functions of the human body are based upon individual DNA sequences.
● Different types of stem cells provide various lines of cells that can contribute to advancements in medicine.</td><td>1. What eukaryotic organelles can one expect to find in a human cell?
2. How do the functions of the organelles relate to the overall function of the human body?
3. How is the importance of the Central Dogma of Biology related to the overall function of the human body?
4. How does movement of particles across the cell membrane relate to homeostasis of the body?</td></tr>
</table>

Course Name:

		5. How has stem cell research advanced and how is it beneficial to modern medicine?
Learning Targets		
Students will… *Describe each kind of cytoplasmic organelle and explain its function.* *Explain how substances move into and out of cells.* *Explain how stem cells make possible growth and repair of tissues.* *Explain how two differentiated cell types can have the same genetic information, but different appearances and functions.*		
Unit Duration:		
3 weeks		

<table>
<tr><th colspan="3"> 
Unit [3]: [Histology]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Using mathematics and computational thinking
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Tissues of the human body are organized into epithelial, muscular, nervous, and connective depending on the overall structure and function it will provide.
● A collection of the same cell type will exist together in order to carry out a specific structure and function of an organ.</td><td>1. What tissues comprise a human body?
2. How are tissues related to overall functions of the human body?
3. How can microscopic images of tissue samples be identified and related to certain locations of the human body?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Describe how cells are organized into tissues.* *List the four major tissue types in the body.* *Describe the general characteristics and functions of epithelial tissues.* *Name the epithelium and identify an organ in which each is found.* *Explain how glands are classified.* *Describe the general characteristics of connective tissue.* *Compare and contrast the components, cells, fibers, and extracellular matrix(where applicable) in each type of connective tissue.* *Describe the major functions of each type of connective tissue.* *Distinguish among the three types of muscle tissue.* *Describe the general characteristics and functions of nervous tissue.*
Unit Duration:
3 weeks

Course Name:

<table>
<tr><th colspan="3"> 
Unit [4]: [Skeletal System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The skeletal system is instrumental in the support, movement, and protection of the body.
● Bones are dynamic organs that interact and support other systems of the body.
● Bone identification and classification is based on size, function, composition, and location.
● Articulation identification and classification is based on function and structure.
● Certain types of bones are composed of specific and complex organization of bone tissue that aid in bone growth and maintenance.</td><td>1. What are the names, locations, and functions of the major bones and parts of the major bones?
2. How is the skeleton involved in support and movement of the body?
3. What are the structures of the internal anatomy of long bones and irregular bones?
4. How is the internal anatomy of bone structure related to how bones grow and are maintained?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Classify bones according to their shapes, and name an example from each group.* *Describe the macroscopic and microscopic structure of a long bone, and list the functions of these parts.* *Explain how bones grow and develop.* *Discuss the major functions of bones.* *Distinguish between the axial and appendicular skeletons, and name the major parts of each.* *Locate and identify the bones and the major features of the bones that comprise the skull, vertebral column, thoracic cage, pectoral girdle, upper limb, pelvic girdle, and lower limb.*
Unit Duration:
3 weeks

Course Name:

<table>
<tr><th colspan="3"> 
Unit [5]: [Muscular System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2
9-12.LS1.A.3
9-12.LS1.C.2</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The muscular system plays a major role in movement, support, and homeostasis of the human body.
● Muscle types vary in structure to support their specific function.
● Muscles are named based on their location and action performed.
● Muscle tissue is composed of a complex and organized system of cells and protein fibers that allow for muscles to contract and relax.</td><td>1. How do the major muscles of the body provide unique functions when they are stimulated?
2. How can the steps of muscle contraction vary the movement outcome of a specific area of the body?
3. What circumstances might affect each of the three types of muscle tissue and how do they cause the muscles of specific organs to respond?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Describe the structure of skeletal muscle.* *Name the major parts of a skeletal muscle fiber and describe the functions of each.* *Describe the neural control of skeletal muscle contraction.* *Identify the major events of skeletal muscle fiber contraction.* *List the energy sources for skeletal muscle fiber contraction.* *Describe how a muscle may become fatigued.* *Distinguish between a twitch and sustained contraction.* *Explain how various types of muscular contractions produce body movements and help maintain posture.* *Explain how the attachments, locations, and interactions of skeletal muscles make possible certain movements.* *Identify and locate the skeletal muscles of each body region and describe the action(s) of each muscle.* *Discuss how exercise can help maintain a healthy muscular system as the body ages.*
Unit Duration:
3 weeks

<table>
<tr><th colspan="3"> 
Unit [6]: [Nervous System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The nervous system senses information, processes that information, and responds using different neurons.
● The function of neurons is related to their specialized structure.
● The human body is composed of different nervous systems organized by various forms of stimuli.
● The sections of the brain and spinal cord are organized by white or gray matter and have specific functions or reflexes associated with each.</td><td>1. How does the body respond to different internal and external stimuli?
2. How is sensory information sent / received from / to the body?
3. How does neural anatomy aid its function?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Describe the parts of a neuron.* *Identify structural and functional differences among neurons.* *Describe the basic ways in which the nervous system processes information.* *Describe the relationship among the brain, brainstem, and spinal cord.* *Describe the coverings of the brain and spinal cord.* *Describe the development of the major parts of the brain and explain the functions of each part.* *Distinguish among sensory, association, and motor areas of the cerebral cortex.* *Discuss hemisphere dominance.* *Explain the stages in memory storage.* *Explain the functions of the limbic systems and the reticular formation.* *Describe the structure of the spinal cord and its major functions.* *Describe the reflex arc and reflex behavior.* *Identify the cranial nerves and list their major functions.* *Distinguish between the sympathetic and parasympathetic divisions of the autonomic nervous system.*
Unit Duration:
4 weeks

Course Name:

<table>
<tr><th colspan="3"> 
Unit [7]: [Cardiopulmonary System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.2
9-12.LS1.A.3</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The heart pumps blood throughout the body which allows for the transfer of oxygen and nutrients to cells, and waste products away from cells.
● The anatomy of organs and structures of the cardiovascular system are directly related to their physiology.
● The respiratory system supplies oxygen to the blood while removing carbon dioxide.
● The anatomy of organs and structures of the respiratory system are directly related to their physiology.</td><td>1. What are the functions of arteries, veins, and capillaries? Relate the structures anatomically to each other.
2. What are the internal and external components of the human heart?
3. How does the conduction of the heart stay regulated?
4. How does the respiratory system deliver oxygen to each cell in the human body?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Explain the roles of the heart and blood vessels in circulating the blood.* *Describe the location of the heart within the body.* *Distinguish between the coverings of the heart and the layers that compose the wall of the heart.* *Identify and locate the major parts of the heart and discuss the function of each part.* *Trace the pathway of the blood through the heart and the vessels of coronary circulation.* *Describe the cardiac cycle and explain how heart sounds are produced.* *Identify the parts of a normal ECG pattern and discuss the significance of this pattern.* *Compare the structures and functions of the major types of blood vessels.* *Describe how substances are exchanged between blood in the capillaries and the tissue fluid surrounding body cells.* *Explain how blood pressure is produced and controlled.* *Compare the pulmonary and systemic circuits of the cardiovascular system.* *Identify and locate the major arteries and veins.* *Name and describe the locations, structure, and function of the organs of the respiratory system.* *Locate the respiratory areas, and explain control of normal breathing.* *Describe the structure and function of the respiratory membrane.* *Explain the importance of partial pressure in diffusion of gases.* *Explain how the blood transports oxygen and carbon dioxide.* *Describe gas exchange in the pulmonary and systemic circuits.*
Unit Duration:
4 weeks

<table>
<tr><th colspan="3"> 
Unit [8]: [Digestive and Excretory System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">9-12.LS1.A.2
9-12.LS1.C.3</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● The digestive system breaks down ingested food to particles small enough to be absorbed into the blood.
● The anatomy of organs and structures of the digestive system are directly related to their movement of digested food through the body.
● The urinary system rids the body of nitrogenous wastes while regulating water, electrolyte, and acid-base balance of the blood.
● The anatomy of organs and structures of the urinary system are directly related to their physiology.</td><td>1. How does the digestive system break down food into usable components and deliver them to each cell in the body?
2. What are the various mechanisms for efficient absorption of nutrients?
3. How do cells rid the body of wasteful byproducts that result from metabolic activities?
4. How does the role of the urinary system contribute to homeostasis?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Name and locate the organs of the digestive system.* *Describe the structure of the wall of the alimentary canal.* *Explain how the contents of the alimentary canal are mixed and moved.* *Describe the functions of the structures associated with the mouth.* *Describe how different types of teeth are adapted for different functions, and list the parts of the tooth.* *Locate each of the salivary glands and describe their function.* *Locate each of the accessory organs(liver, gallbladder, and pancreas) and describe their functions and relationship with digestive enzymes and substances.* *Trace the pathway of a bolus through each organ of the alimentary canal starting in the mouth and ending with the anus and describe their functions.* *Describe how digestive secretions are regulated.* *Describe the mechanisms of swallowing, vomiting, and defecating.* *Explain how the products of digestion are absorbed.* *Name the organs of the urinary system and list their functions.* *Describe the locations, structures and functions of the kidneys.* *Describe a nephron and explain the functions of its major parts.* *Explain how the final composition of urine contributes to homeostasis.*
Unit Duration:
4 weeks

<table>
<tr><th colspan="3"> 
Unit [9]: [Endocrine System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS1.A.3</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The endocrine system is a complex network of glands, tissues, and hormones that work in tandem with other body systems.
● Hormones are an integral part of maintaining homeostasis within the body.</td><td>1. What are the primary structures in the endocrine system and how do they work in concert with one another?
2. How does the endocrine system maintain homeostasis?</td></tr>
</table>

Course Name:

Learning Targets
Students will… *Distinguish between endocrine and exocrine glands.* *Explain what makes a target cell for a hormone.* *List important functions of hormones.* *Describe how hormones can be classified according to their chemical composition.* *Explain how steroid and nonsteroid hormones affect their target cells.* *Discuss how negative feedback mechanisms regulate hormone secretion.* *Explain how the nervous system controls hormone secretion.* *Name and describe the locations of the major endocrine glands and list the hormones that they secrete.* *Describe the actions of the various hormones and their contributions to homeostasis.* *Explain how the secretion of each hormone is regulated.*
Unit Duration:
2.5 weeks

Course Name:

<table>
<tr><th colspan="3"> 
Unit [10]: [Reproductive System]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">9-12.LS1.A.2
9-12.LS1.A.3</td><td colspan="2">● Asking Questions and Defining Problems
● Developing and using models
● Planning and carrying out investigations
● Analyzing and interpreting data
● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
</table>

	● The cellular structures of the male and female reproductive systems provide a pathway for reproduction of the human body. ● Hormones for the male anatomy serve an important role in the production and protection of sperm. ● Female reproductive anatomy relies upon a complex cycle of hormones for the maturation of eggs and growth of a fetus. ● Pregnancy results in various changes of the female reproductive organs as well as the fetus.	**1. What are the reproductive system organs and their functions in both males and females?** **2. What pathway do sperm travel from the testes to the exterior of the body?** **3. How do hormones regulate the reproductive organs of males and females?** **4. What is the structure of sperm and how does it relate to its function?** **5. What are the similarities and differences between spermatogenesis and oogenesis?** **6. What are the phases and controls of the menstrual cycle?** **7. What is the difference between implantation and fertilization?** **8. How is a female's body altered by pregnancy?** **9. Why is the presence or absence of testosterone important during embryonic development of the reproductive organs?** **10. What are the stages from fertilization to delivery?**

Course Name:

Learning Targets
Students will… *Describe the structure and function(s) of each part of the male reproductive system.* *Outline the process of spermatogenesis.* *Describe semen production and exit from the body.* *Explain how hormones control the activities of the males reproductive organs and the development of male secondary sex characteristics.* *Describe the structure and function(s) of each part of the female reproductive system.* *Outline the process of oogenesis.* *Explain how hormones control the activities of the female reproductive organs and the development of female secondary sex characteristtics.* *Describe the major events during a female reproductive cycle.* *Describe several methods of birth control, including the relative effectiveness of each method.* *List the general symptoms of diseases associated with sexually transmitted infections.* *Trace the movement of sperm toward an egg.* *Describe, in detail, fertilization.* *Discuss the hormonal and other changes in the maternal body during pregnancy.* *Explain the role of hormones in the birth process and milk production.*
Unit Duration:
4 weeks

Standard: *LS1.A.1*			
Topic: Cytology			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ***Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.]*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS1.A.2*			
Topic: Anatomical Terminology, Histology, Skeletal System, Muscular System, Nervous System, Digestive/Excretory System, Reproductive System			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ***Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.]*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS1.A.3*			
Topic: Cytology, Muscular System, Cardiopulmonary System, Endocrine System, Reproductive System			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ***Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification*** ***Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.]*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS1.C.2*			
Topic: Muscular System			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ***Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.]*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: *LS1.C.3*			
Topic: Digestive and Excretory System			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ***Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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[AP/CC Biology] *Course Overview*	
Grade level(s): 11-12	**Credits earned:** .5 Credits Per Semester (AP TEST/ CC OPTION)
Course Rationale	**Course Description**
AP Biology Course and Exam Description This class is designed to instruct **advanced, highly motivated** high school students in fundamental college level biological concepts. This class is for students with a strong background in science and for those who may choose to pursue a career in a science-related field. Advanced Placement Biology is designed to expose high school students to the same rigors and experiences they would encounter in an introductory college biology course.	This course is equivalent to a college level introductory biology course. Students cultivate their understanding through inquiry-based investigations as they explore the following topics: evolution, cellular processes, energy and communication, genetics, information, ecology and interactions. It is expected that students take the AP Biology exam at the end of the school year (3 or above to get college credit) or make a C or above in the class to obtain college credit.
Transfer Goals/Big Ideas	
• **Tips for Teaching Transfer Goals** • **Transfer Goal Article** • **Understanding By Design Guide Advanced Concepts in Creating and Reviewing Units** • **Transfer Goal Examples** • **Big Ideas**	
Priority Missouri Learning Standards/National Standards	

Science Practice 1: Explain biological concepts, processes, and models presented in written format.
Science Practice 2: Analyze visual representations of biological concepts and processes.
Science Practice 3: Determine scientific questions and methods.
Science Practice 4: Represent and describe data.
Science Practice 5: Perform statistical tests and mathematical calculations to analyze and interpret data.
Science Practice 6: Develop and justify scientific arguments using evidence.

Science Practice 1	Science Practice 2	Science Practice 3
Concept Explanation 1 Explain biological concepts, processes, and models presented in written format.	***Visual Representations*** 2 Analyze visual representations of biological concepts and processes.	***Questions and Methods*** 3 Determine scientific questions and methods.
1.A Describe biological concepts and/or processes. 1.B Explain biological concepts and/or processes. 1.C Explain biological concepts, processes, and/or models in applied contexts.	2.A Describe characteristics of a biological concept, process, or model represented visually. 2.B Explain relationships between different characteristics of biological concepts, processes, or models represented visually a. In theoretical contexts. b. In applied contexts. 2.C Explain how biological concepts or processes represented visually relate to larger biological principles, concepts, processes, or theories. 2.D Represent relationships within biological models, including a. Mathematical models. b. Diagrams. c. Flow charts.	3.A Identify or pose a testable question based on an observation, data, or a model. 3.B State the null and alternative hypotheses, or predict the results of an experiment. 3.C Identify experimental procedures that are aligned to the question, including a. Identifying dependent and independent variables. b. Identifying appropriate controls. c. Justifying appropriate controls. 3.D Make observations, or collect data from representations of laboratory setups or results. (Lab only; not assessed) 3.E Propose a new/next investigation based on a. An evaluation of the evidence from an experiment. b. An evaluation of the design/methods.

Science Practice 4	Science Practice 5	Science Practice 6
Representing and Describing Data 4 Represent and describe data.	***Statistical Tests and Data Analysis*** 5 Perform statistical tests and mathematical calculations to analyze and interpret data.	***Argumentation*** 6 Develop and justify scientific arguments using evidence.
4.A Construct a graph, plot, or chart (*X,Y; Log Y; Bar; Histogram; Line, Dual Y; Box and Whisker; Pie*). a. Orientation b. Labeling c. Units d. Scaling e. Plotting f. Type g. Trend line 4.B Describe data from a table or graph, including a. Identifying specific data points. b. Describing trends and/or patterns in the data. c. Describing relationships between variables.	5.A Perform mathematical calculations, including a. Mathematical equations in the curriculum. b. Means. c. Rates. d. Ratios. e. Percentages. 5.B Use confidence intervals and/or error bars (both determined using standard errors) to determine whether sample means are statistically different. 5.C Perform chi-square hypothesis testing. 5.D Use data to evaluate a hypothesis (or prediction), including a. Rejecting or failing to reject the null hypothesis. b. Supporting or refuting the alternative hypothesis.	6.A Make a scientific claim. 6.B Support a claim with evidence from biological principles, concepts, processes, and/or data. 6.C Provide reasoning to justify a claim by connecting evidence to biological theories. 6.D Explain the relationship between experimental results and larger biological concepts, processes, or theories. 6.E Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a. Biological concepts or processes. b. A visual representation of a biological concept, process, or model. c. Data.

9-12 LS1-A-3- Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.(NGSS: HS-LS1-3)
9-12 LS1-C-1- Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. (NGSS: HS-LS1-5)

9-12 LS2-B-1- Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow. (NGSS: HS-LS2-3) 9-12 LS3-B-2-Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure (NGSS: MS-LS3-2.) 9-12 LS4-C-2-Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.(NGSS: HS-LS4-5)

Unit [1]: [Chemistry of Life 8-11%]

Desired Results

Standards	**Transfer Goal(s) /Big Ideas**	
BIG IDEA 2 Energetics ENE *What is the role of energy in the making and breaking of polymers?* *BIG IDEA 3 Info Storage and Transmission IST* *How do living systems transmit information in order to ensure their survival?* *BIG IDEA 4 Systems Interactions SYI* *How would living systems function without the polarity of the water molecule?*		
	Enduring Understandings	**Learning Objectives**
	What are enduring understandings? **1.1: Structure of Water and Hydrogen Bonding** SYI-1 Living systems are organized in a hierarchy of structural levels that interact. **1.2: Elements of Life**	*What are essential Questions?* SYI-1.A Explain how the properties of water that result from its polarity and hydrogen bonding affect its biological function.

9-12.LS1.C.3	ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules. **1.3: Introduction to Biological Macromolecules** SYI-1 Living systems are organized in a hierarchy of structural levels that interact. **1.4: Properties of Biological Macromolecules** SYI-1 Living systems are organized in a hierarchy of structural levels that interact. **1.5: Structure and Function of Biological Macromolecules** SYI-1 Living systems are organized in a hierarchy of structural levels that interact. **1.6: Nucleic Acids** IST-1 Heritable information provides for continuity of life.	ENE-1.A Describe the composition of macromolecules required by living organisms. SYI-1.B Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules. SYI-1.B Describe the properties of the monomers and the type of bonds that connect the monomers in biological macromolecules. SYI-1.C Explain how a change in the subunits of a polymer may lead to changes in structure or function of the macromolecule. IST-1.A Describe the structural similarities and differences between DNA and RNA.

Essential Knowledge

Students will…
SYI-1.A.1 The subcomponents of biological molecules and their sequence determine the properties of that molecule.
SYI-1.A.2 Living systems depend on properties of water that result from its polarity and hydrogen bonding.
SYI-1.A.3 The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.
SYI-1.A.2 Living systems depend on properties of water that result from its polarity and hydrogen bonding.
SYI-1.A.3 The hydrogen bonds between water molecules result in cohesion, adhesion, and surface tension.
ENE-1.A.1 Organisms must exchange matter with the environment to grow, reproduce, and maintain organization.
ENE-1.A.2 Atoms and molecules from the environment are necessary to build new molecules— a. Carbon is used to build biological molecules such as carbohydrates, proteins, lipids, and nucleic acids. Carbon is used in storage compounds and cell formation in all organisms. b. Nitrogen is used to build proteins and nucleic acids. Phosphorus is used to build nucleic acids and certain lipids.
SYI-1.B.1 Hydrolysis and dehydration synthesis are used to cleave and form covalent bonds between monomers.

SYI-1.B.2 Structure and function of polymers are derived from the way their monomers are assembled— a. In nucleic acids, biological information is encoded in sequences of nucleotide monomers. Each nucleotide has structural components: a five-carbon sugar (deoxyribose or ribose), a phosphate, and a nitrogen base (adenine, thymine, guanine, cytosine, or uracil). DNA and RNA differ in structure and function. b. In proteins, the specific order of amino acids in a polypeptide (primary structure) determines the overall shape of the protein. Amino acids have directionality, with an amino (NH2) terminus and a carboxyl (COOH) terminus. The R group of an amino acid can be categorized by chemical properties (hydrophobic, hydrophilic, or ionic), and the interactions of these R groups determine structure and function of that region of the protein. c. Complex carbohydrates comprise sugar monomers whose structures determine the properties and functions of the molecules. d. Lipids are nonpolar macromolecules— i. Differences in saturation determine the structure and function of lipids. ii. Phospholipids contain polar regions that interact with other polar molecules, such as water, and with nonpolar regions that are often hydrophobic. *SYI-1.C.1 Directionality of the subcomponents influences structure and function of the polymer— a. Nucleic acids have a linear sequence of nucleotides that have ends, defined by the 3' hydroxyl and 5' phosphates of the sugar in the nucleotide. During DNA and RNA synthesis, nucleotides are added to the 3' end of the growing strand, resulting in the formation of a covalent bond between nucleotides. b. DNA is structured as an antiparallel double helix, with each strand running in opposite 5' to 3' orientation. Adenine nucleotides pair with thymine nucleotides via two hydrogen bonds. Cytosine nucleotides pair with guanine nucleotides by three hydrogen bonds. c. Proteins comprise linear chains of amino acids, connected by the formation of covalent bonds at the carboxyl terminus of the growing peptide chain. d. Proteins have primary structure determined by the sequence order of their constituent amino acids, secondary structure that arises through local folding of the amino acid chain into elements such as alpha-helices and beta-sheets, tertiary structure that is the overall three-dimensional shape of the protein and often minimizes free energy, and quaternary structure that arises from interactions between multiple polypeptide units. The four elements of protein structure determine the function of a protein. e. Carbohydrates comprise linear chains of sugar monomers connected by covalent bonds. Carbohydrate polymers may be linear or branched.* *IST-1.A.1 DNA and RNA molecules have structural similarities and differences related to their function— a. Both DNA and RNA have three components—sugar, a phosphate group, and a nitrogenous base—that form nucleotide units that are connected by covalent bonds to form a linear molecule with 5' and 3' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone. b. The basic structural differences between DNA and RNA include the following: i. DNA contains deoxyribose and RNA contains ribose. ii. RNA contains uracil and DNA contains thymine. iii. DNA is usually double stranded; RNA is usually single stranded. iv. The two DNA strands in double-stranded DNA are antiparallel in directionality*
Unit Duration:
8-11% (6 Blocks)

<table>
<tr><th colspan="3"> 
Unit [2]: [Cell Structure and Function 10-13%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 1 Evolution EVO
Defend the origin of eukaryotic cells.
BIG IDEA 2 Energetics ENE
How do the mechanisms for transport across membranes support energy conservation? What are the advantages and disadvantages of cellular compartmentalization?
BIG IDEA 4 Systems Interactions SYI
How are living systems affected by the presence or absence of subcellular components?

9-12.LS1.A.2</td><td></td><td></td></tr>
<tr><td>Enduring Understandings

What are enduring understandings?

SYI-1 Living systems are organized in a hierarchy of structural levels that interact.
SYI-1 Living systems are organized in a hierarchy of structural levels that interact.
ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
ENE-2 Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments.
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What are essential Questions?

SYI-1.D Describe the structure and/ or function of subcellular components and organelles.
SYI-1.E Explain how subcellular components and organelles contribute to the function of the cell.
SYI-1.F Describe the structural features of a cell that allow organisms to capture, store, and use energy
ENE-1.B Explain the effect of surface area-to-volume ratios on the exchange of materials between cells or organisms and the environment.
ENE-1.C Explain how specialized structures and strategies are used for the efficient exchange of molecules to the environment.
ENE-2.A Describe the roles of each of the components of the cell membrane in maintaining the internal environment of the cell.</td></tr>
</table>

	ENE-2 Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments. ENE-2 Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments. ENE-2 Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments. ENE-2 Cells have membranes that allow them to establish and maintain internal environments that are different from their external environments. EVO-1 Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.	ENE-2.B Describe the Fluid Mosaic Model of cell membranes. ENE-2.C Explain how the structure of biological membranes influences selective permeability. ENE-2.D Describe the role of the cell wall in maintaining cell structure and function. ENE-2.E Describe the mechanisms that organisms use to maintain solute and water balance. ENE-2.F Describe the mechanisms that organisms use to transport large molecules across the plasma membrane. ENE-2.G Explain how the structure of a molecule affects its ability to pass through the plasma membrane. ENE-2.H Explain how concentration gradients affect the movement of molecules across membranes. ENE-2.I Explain how osmoregulatory mechanisms contribute to the health and survival of organisms. ENE-2.J Describe the processes that allow ions and other molecules to move across membranes. ENE-2.K Describe the membrane bound structures of the eukaryotic cell. ENE-2.L Explain how internal membranes and membrane bound organelles contribute to compartmentalization of eukaryotic cell functions. EVO-1.A Describe similarities and/or differences in compartmentalization between prokaryotic and eukaryotic cells.

		EVO-1.B Describe the relationship between the functions of endosymbiotic organelles and their free-living ancestral counterparts.

Essential Knowledge

SYI-1.D.1 Ribosomes comprise ribosomal RNA (rRNA) and protein. Ribosomes synthesize protein according to mRNA sequence.
SYI-1.D.2 Ribosomes are found in all forms of life, reflecting the common ancestry of all known life.
SYI-1.D.3 Endoplasmic reticulum (ER) occurs in two forms—smooth and rough. Rough ER is associated with membrane-bound ribosomes— a. Rough ER compartmentalizes the cell. b. Smooth ER functions include detoxification and lipid synthesis.
SYI-1.D.4 The Golgi complex is a membrane-bound structure that consists of a series of flattened membrane sacs— a. Functions of the Golgi include the correct folding and chemical modification of newly synthesized proteins and packaging for protein trafficking.
SYI-1.D.5 Mitochondria have a double membrane. The outer membrane is smooth, but the inner membrane is highly convoluted, forming folds.
SYI-1.D.6 Lysosomes are membrane-enclosed sacs that contain hydrolytic enzymes.
SYI-1.D.7 A vacuole is a membrane-bound sac that plays many and differing roles. In plants, a specialized large vacuole serves multiple functions.
SYI-1.D.8 Chloroplasts are specialized organelles that are found in photosynthetic algae and plants. Chloroplasts have a double outer membrane.
SYI-1.E.1 Organelles and subcellular structures, and the interactions among them, support cellular function— a. Endoplasmic reticulum provides mechanical support, carries out protein synthesis on membrane-bound ribosomes, and plays a role in intracellular transport. b. Mitochondrial double membrane provides compartments for different metabolic reactions. c. Lysosomes contain hydrolytic enzymes, which are important in intracellular digestion, the recycling of a cell's organic materials, and programmed cell death (apoptosis). d. Vacuoles have many roles, including storage and release of macromolecules and cellular waste products. In plants, it aids in retention of water for turgor pressure.
SYI-1.F.1 The folding of the inner membrane increases the surface area, which allows for more ATP to be synthesized.
SYI-1.F.2 Within the chloroplast are thylakoids and the stroma.
SYI-1.F.3 The thylakoids are organized in stacks, called grana.
SYI-1.F.4 Membranes contain chlorophyll pigments and electron transport proteins that comprise the photosystems.
SYI-1.F.5 The light-dependent reactions of photosynthesis occur in the grana.
SYI-1.F.6 The stroma is the fluid within the inner chloroplast membrane and outside of the thylakoid.
SYI-1.F.7 The carbon fixation (Calvin-Benson cycle) reactions of photosynthesis occur in the stroma.
SYI-1.F.8 The Krebs cycle (citric acid cycle) reactions occur in the matrix of the mitochondria.

SYI-1.F.9 Electron transport and ATP synthesis occur on the inner mitochondrial membrane.
ENE-1.B.1 Surface area-to-volume ratios affect the ability of a biological system to obtain necessary resources, eliminate waste products, acquire or dissipate thermal energy, and otherwise exchange chemicals and energy with the environment.
ENE-2.C.1 The structure of cell membranes results in selective permeability.
ENE-2.C.2 Cell membranes separate the internal environment of the cell from the external environment.
ENE-2.C.3 Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.
ENE-2.C.4 Small nonpolar molecules, including N2, O2, and CO2 , freely pass across the membrane. Hydrophilic substances, such as large polar molecules and ions, move across the membrane through embedded channel and transport proteins.
ENE-2.C.5 Polar uncharged molecules, including H2O, pass through the membrane in small amounts.
ENE-2.D.1 Cell walls provide a structural boundary, as well as a permeability barrier for some substances to the internal environments.
ENE-2.D.2 Cell walls of plants, prokaryotes, and fungi are composed of complex carbohydrates.

RELEVANT EQUATIONS

Volume of a Sphere: $V = \frac{4}{3}\pi r^3$

Volume of a Cube: $V = s^2$

Volume of a Rectangular Solid: $V = lwh$

Volume of a Cylinder: $V = \pi r^2 h$

Surface Area of a Sphere: $SA = 4\pi r^2$

Surface Area of a Cube: $SA = 6s^2$

Surface Area of a Rectangular Solid:
$SA = 2lh + 2lw + 2wh$

Surface Area of a Cylinder: $SA = 2\pi rh + 2\pi r^2$

r = radius
l = length
h = height
w = width
s = length of one side of a cube

ENE-1.B.2 The surface area of the plasma membrane must be large enough to adequately exchange materials— a. These limitations can restrict cell size and shape. Smaller cells typically have a higher surface area-to-volume ratio and more efficient exchange of materials with the environment. b. As cells increase in volume, the relative surface area decreases and the demand for internal resources increases. c. More complex cellular structures (e.g., membrane folds) are necessary to adequately exchange materials with the environment. d. As organisms increase in size, their surface area-to-volume ratio decreases, affecting properties like rate of heat exchange with the environment.
ENE-1.C.1 Organisms have evolved highly efficient strategies to obtain nutrients and eliminate wastes. Cells and organisms use specialized exchange surfaces to obtain and release molecules from or into the surrounding environment.

ENE-2.A.1 Phospholipids have both hydrophilic and hydrophobic regions. The hydrophilic phosphate regions of the phospholipids are oriented toward the aqueous external or internal environments, while the hydrophobic fatty acid regions face each other within the interior of the membrane.
ENE-2.A.2 Embedded proteins can be hydrophilic, with charged and polar side groups, or hydrophobic, with nonpolar side groups.
ENE-2.B.1 Cell membranes consist of a structural framework of phospholipid molecules that is embedded with proteins, steroids (such as cholesterol in eukaryotes), glycoproteins, and glycolipids that can flow around the surface of the cell within the membrane.
ENE-2.E.1 Passive transport is the net movement of molecules from high concentration to low concentration without the direct input of metabolic energy.
ENE-2.E.2 Passive transport plays a primary role in the import of materials and the export of wastes.
ENE-2.E.3 Active transport requires the direct input of energy to move molecules from regions of low concentration to regions of high concentration.
ENE-2.F.1 The selective permeability of membranes allows for the formation of concentration gradients of solutes across the membrane.
ENE-2.F.2 The processes of endocytosis and exocytosis require energy to move large molecules into and out of cells— a. In exocytosis, internal vesicles fuse with the plasma membrane and secrete large macromolecules out of the cell. b. In endocytosis, the cell takes in macromolecules and particulate matter by forming new vesicles derived from the plasma membrane.
ENE-2.G.1 Membrane proteins are required for facilitated diffusion of charged and large polar molecules through a membrane— a. Large quantities of water pass through aquaporins. b. Charged ions, including Na+ and K+, require channel proteins to move through the membrane. c. Membranes may become polarized by movement of ions across the membrane
ENE-2.G.2 Membrane proteins are necessary for active transport.
ENE-2.G.3 Metabolic energy (such as from ATP) is required for active transport of molecules and/ or ions across the membrane and to establish and maintain concentration gradients.
ENE-2.G.4 The Na+/K+ ATPase contributes to the maintenance of the membrane potential.
ENE-2.H.1 External environments can be hypotonic, hypertonic or isotonic to internal environments of cells— a. Water moves by osmosis from areas of high water potential/low osmolarity/ low solute concentration to areas of low water potential/high osmolarity/high solute concentration.

RELEVANT EQUATION

Water Potential:

$$\Psi = \Psi_p + \Psi_s$$

Ψ_p = pressure potential

Ψ_s = solute potential

ENE-2.I.1 Growth and homeostasis are maintained by the constant movement of molecules across membranes.

ENE-2.I.2 Osmoregulation maintains water balance and allows organisms to control their internal solute composition/water potential.

SOLUTE POTENTIAL OF A SOLUTION

$$\Psi_s = -iCRT$$

where:

i = ionization constant

C = molar concentration

R = pressure constant

$$\left(R = 0.0831 \frac{L \bullet bars}{mol \bullet K} \right)$$

T = temperature in Kelvin (°C + 273)

ENE-2.J.1 A variety of processes allow for the movement of ions and other molecules across membranes, including passive and active transport, endocytosis and exocytosis.
ENE-2.K.1 Membranes and membrane-bound organelles in eukaryotic cells compartmentalize intracellular metabolic processes and specific enzymatic reactions.
ENE-2.L.1 Internal membranes facilitate cellular processes by minimizing competing interactions and by increasing surface areas where reactions can occur.
EVO-1.A.1 Membrane-bound organelles evolved from once free-living prokaryotic cells via endosymbiosis.
EVO-1.A.2 Prokaryotes generally lack internal membrane bound organelles but have internal regions with specialized structures and functions.
EVO-1.A.3 Eukaryotic cells maintain internal membranes that partition the cell into specialized regions.
EVO-1.B.1 Membrane-bound organelles evolved from previously free-living prokaryotic cells via endosymbiosis.

Unit Duration:

<table>
<tr><th colspan="3"> 
Unit [3]: [Cellular Energetics 12-16%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">BIG IDEA 2 Energetics ENE
How is energy captured and then used by a living system?
BIG IDEA 4 Systems Interactions SYI
How do organisms use energy or conserve energy to respond to environmental stimuli?
9-12.LS1.C.1
9-12.LS1.C.2
9-12.LS2.B.1
9-12.LS2.B.3</td><td colspan="2"></td></tr>
<tr><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td>ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
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ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.</td><td>ENE-1.D Describe the properties of enzymes.
ENE-1.E Explain how enzymes affect the rate of biological reactions.
ENE-1.F Explain how changes to the structure of an enzyme may affect its function.
ENE-1.G Explain how the cellular environment affects enzyme activity.
ENE-1.H Describe the role of energy in living organisms.
ENE-1.I Describe the photosynthetic processes that allow organisms to capture and store energy.
ENE-1.J Explain how cells capture energy from light and transfer it to biological molecules for storage and use.
ENE-1.K Describe the processes that allow organisms to use energy stored in biological macromolecules.</td></tr>
</table>

	SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	ENE-1.L Explain how cells obtain energy from biological macromolecules in order to power cellular functions. SYI-3.A Explain the connection between variation in the number and types of molecules within cells to the ability of the organism to survive and/or reproduce in different environments.

Essential Knowledge

ENE-1.D.1 The structure of enzymes includes the active site that specifically interacts with substrate molecules.
ENE-1.D.2 For an enzyme-mediated chemical reaction to occur, the shape and charge of the substrate must be compatible with the active site of the enzyme.
ENE-1.E.1 The structure and function of enzymes contribute to the regulation of biological processes— a. Enzymes are biological catalysts that facilitate chemical reactions in cells by lowering the activation energy.
ENE-1.F.1 Change to the molecular structure of a component in an enzymatic system may result in a change of the function or efficiency of the system— a. Denaturation of an enzyme occurs when the protein structure is disrupted, eliminating the ability to catalyze reactions. b. Environmental temperatures and pH outside the optimal range for a given enzyme will cause changes to its structure, altering the efficiency with which it catalyzes reactions.
ENE-1.F.2 In some cases, enzyme denaturation is reversible, allowing the enzyme to regain activity.
ENE-1.G.1 Environmental pH can alter the efficiency of enzyme activity, including through disruption of hydrogen bonds that provide enzyme structure.

RELEVANT EQUATION

$$pH = -\log[H^+]$$

ENE-1.G.2 The relative concentrations of substrates and products determine how efficiently an enzymatic reaction proceeds.
ENE-1.G.3 Higher environmental temperatures increase the speed of movement of molecules in a solution, increasing the frequency of collisions between enzymes and substrates and therefore increasing the rate of reaction.
ENE-1G.4 Competitive inhibitor molecules can bind reversibly or irreversibly to the active site of the enzyme. Noncompetitive inhibitors can bind allosteric sites, changing the activity of the enzyme.
ENE-1.H.1 All living systems require constant input of energy.

ENE-1.H.2 Life requires a highly ordered system and does not violate the second law of thermodynamics— a. Energy input must exceed energy loss to maintain order and to power cellular processes. b. Cellular processes that release energy may be coupled with cellular processes that require energy. C. Loss of order or energy flow results in death.
ENE-1.H.3 Energy-related pathways in biological systems are sequential to allow for a more controlled and efficient transfer of energy. A product of a reaction in a metabolic pathway is generally the reactant for the subsequent step in the pathway.
ENE-1.I.1 Organisms capture and store energy for use in biological processes— a. Photosynthesis captures energy from the sun and produces sugars. i. Photosynthesis first evolved in prokaryotic organisms. ii. Scientific evidence supports the claim that prokaryotic (cyanobacterial) photosynthesis was responsible for the production of an oxygenated atmosphere. iii. Prokaryotic photosynthetic pathways were the foundation of eukaryotic photosynthesis.
ENE-1.I.2 The light-dependent reactions of photosynthesis in eukaryotes involve a series of coordinated reaction pathways that capture energy present in light to yield ATP and NADPH, which power the production of organic molecules.
ENE-1.J.1 During photosynthesis, chlorophylls absorb energy from light, boosting electrons to a higher energy level in photosystems I and II.
ENE-1.J.2 Photosystems I and II are embedded in the internal membranes of chloroplasts and are connected by the transfer of higher energy electrons through an electron transport chain (ETC).
ENE-1.J.3 When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) is established across the internal membrane.
ENE-1.J.4 The formation of the proton gradient is linked to the synthesis of ATP from ADP and inorganic phosphate via ATP synthase.
ENE-1.J.5 The energy captured in the light reactions and transferred to ATP and NADPH powers the production of carbohydrates from carbon dioxide in the Calvin cycle, which occurs in the stroma of the chloroplast.
ENE-1.K.1 Fermentation and cellular respiration use energy from biological macromolecules to produce ATP. Respiration and fermentation are characteristic of all forms of life.
ENE-1.K.2 Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that capture energy from biological macromolecules.
ENE-1.K.3 The electron transport chain transfers energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes— a. Electron transport chain reactions occur in chloroplasts, mitochondria, and prokaryotic plasma membranes. b. In cellular respiration, electrons delivered by NADH and FADH are passed to a series of electron acceptors as they move toward the terminal electron acceptor, oxygen. In photosynthesis, the terminal electron acceptor is NADP+. Aerobic prokaryotes use oxygen as a terminal electron acceptor, while anaerobic prokaryotes use other molecules. c. The transfer of electrons is accompanied by the formation of a proton gradient across the inner mitochondrial membrane or the internal membrane of chloroplasts, with the membrane(s) separating a region of high proton concentration from a region of low proton concentration. In prokaryotes, the passage of electrons is accompanied by the movement of protons across the plasma membrane. d. The flow of protons back through membrane-bound ATP synthase by chemiosmosis drives the formation of ATP from ADP and inorganic phosphate. This is known as oxidative phosphorylation in cellular respiration, and photophosphorylation in

photosynthesis. e. n cellular respiration, decoupling oxidative phosphorylation from electron transport generates heat. This heat can be used by endothermic organisms to regulate body temperature. *ENE-1.L.1 Glycolysis is a biochemical pathway that releases energy in glucose to form ATP from ADP and inorganic phosphate, NADH from NAD+, and pyruvate.* *ENE-1.L.2 Pyruvate is transported from the cytosol to the mitochondrion, where further oxidation occurs.* *ENE-1.L.3 In the Krebs cycle, carbon dioxide is released from organic intermediates, ATP is synthesized from ADP and inorganic phosphate, and electrons are transferred to the coenzymes NADH and FADH2.* *ENE-1.L.4 Electrons extracted in glycolysis and Krebs cycle reactions are transferred by NADH and FADH2 to the electron transport chain in the inner mitochondrial membrane.* *ENE-1.L.5 When electrons are transferred between molecules in a sequence of reactions as they pass through the ETC, an electrochemical gradient of protons (hydrogen ions) across the inner mitochondrial membrane is established.* *ENE-1.L.6 Fermentation allows glycolysis to proceed in the absence of oxygen and produces organic molecules, including alcohol and lactic acid, as waste products.* *ENE-1.L.7 The conversion of ATP to ADP releases energy, which is used to power many metabolic processes.* *SYI-3.A.1 Variation at the molecular level provides organisms with the ability to respond to a variety of environmental stimuli.* *SYI-3.A.2 Variation in the number and types of molecules within cells provides organisms a greater ability to survive and/or reproduce in different environments.*
Unit Duration:

<table>
<tr><th colspan="3">Unit [4]: [Cell Communication and Cell Cycle 10-15%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 2 Energetics ENE
In what ways do cells use energy to communicate with one another?
BIG IDEA 3 Info Storage and Transmission IST
How does the cell cycle aid in the conservation of genetic information? § Why and in what ways do cells communicate with one another?

9-12.LS1.A.3
9-12.LS1.B.1</td><td></td><td></td></tr>
<tr><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td></td><td>IST-3 Cells communicate by generating, transmitting, receiving, and responding to chemical signals.
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ENE-3 Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
IST-1 Heritable information provides for continuity of life.</td><td>IST-3.A Describe the ways that cells can communicate with one another.
IST-3.B Explain how cells communicate with one another over short and long distances.
IST-3.C Describe the components of a signal transduction pathway.
IST-3.D Describe the role of components of a signal transduction pathway in producing a cellular response.
IST-3.E Describe the role of the environment in eliciting a cellular response.
IST-3.F Describe the different types of cellular responses elicited by a signal transduction pathway.
IST-3.G Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.
ENE-3.A Describe positive and/ or negative feedback mechanisms.</td></tr>
</table>

	IST-1 Heritable information provides for continuity of life.	ENE-3.B Explain how negative feedback helps to maintain homeostasis. ENE-3.C Explain how positive feedback affects homeostasis. IST-1.B Describe the events that occur in the cell cycle IST-1.C Explain how mitosis results in the transmission of chromosomes from one generation to the next. IST-1.E Describe the effects of disruptions to the cell cycle on the cell or organism.
Essential Knowledge		
IST-3.A.1 Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling— a. Cells communicate by cell-to-cell contact. *IST-3.B.1 Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell — a. Signals released by one cell type can travel long distances to target cells of another cell type.* *IST-3.C.1 Signal transduction pathways link signal reception with cellular responses. IST-3.C.2 Many signal transduction pathways include protein modification and phosphorylation cascades.* *IST-3.D.1 Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell— a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship. b. G protein-coupled receptors are an example of a receptor protein in eukaryotes.* *IST-3.D.2 Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression—a. After the ligand binds, the intracellular domain of a receptor protein changes shape initiating transduction of the signal. b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal. c. Binding of ligand-to-ligand-gated channels can cause the channel to open or close.* *IST-3.E.1 Signal transduction pathways influence how the cell responds to its environment.*		

IST-3.F.1 Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis). *IST-3.G.1 Changes in signal transduction pathways can alter cellular response— a. Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal.* *IST-3.G.2 Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway* *ENE-3.A.1 Organisms use feedback mechanisms to maintain their internal environments and respond to internal and external environmental changes.* *ENE-3.B.1 Negative feedback mechanisms maintain homeostasis for a particular condition by regulating physiological processes. If a system is perturbed, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular and cellular levels.* *ENE-3.C.1 Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set point. Amplification occurs when the stimulus is further activated, which, in turn, initiates an additional response that produces system change.* *IST-1.B.1 In eukaryotes, cells divide and transmit genetic information via two highly regulated processes.* *IST-1.B.2 The cell cycle is a highly regulated series of events for the growth and reproduction of cells— a. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis. b. A cell can enter a stage (G0) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.* *IST-1.C.1 Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells— a. Mitosis plays a role in growth, tissue repair, and asexual reproduction. b. Mitosis alternates with interphase in the cell cycle. c. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).* *IST-1.D.1 A number of internal controls or checkpoints regulate progression through the cycle.* *IST-1.D.2 Interactions between cyclins and cyclin-dependent kinases control the cell cycle.* *IST-1.E.1 Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).*
Unit Duration:

<table>
<tr><th colspan="3"> 
Unit [5]: [Heredity 8-11%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 1 Evolution EVO § How is our understanding of evolution influenced by our knowledge of genetics?
BIG IDEA 3 Info Storage and Transmission IST
Why is it important that not all inherited characteristics get expressed in the next generation?
How would Mendel’s laws have been affected if he had studied a different type of plant?
BIG IDEA 4 Systems Interactions SYI
How does the diversity of a species affect inheritance?

9-12.LS4.A.1
9-12.LS3.B.3
9-12.LS3.A.1</td><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td>IST-1 Heritable information provides for continuity of life.
IST-1 Heritable information provides for continuity of life.
EVO-2 Organisms are linked by lines of descent from common ancestry.
IST-1 Heritable information provides for continuity of life.
IST-1 Heritable information provides for continuity of life.
SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment.</td><td>IST-1.F Explain how meiosis results in the transmission of chromosomes from one generation to the next.
IST-1.G Describe similarities and/ or differences between the phases and outcomes of mitosis and meiosis.
IST-1.H Explain how the process of meiosis generates genetic diversity.
EVO-2.A Explain how shared, conserved, fundamental processes and features support the concept of common ancestry for all organisms.
IST-1.I Explain the inheritance of genes and traits as described by Mendel’s laws.
IST-1.J Explain deviations from Mendel’s model of the inheritance of traits.</td></tr>
</table>

	SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment.	SYI-3.B Explain how the same genotype can result in multiple phenotypes under different environmental conditions. SYI-3.C Explain how chromosomal inheritance generates genetic variation in sexual reproduction
Essential Knowledge		
IST-1.F.1 Meiosis is a process that ensures the formation of haploid gamete cells in sexually reproducing diploid organisms— a. Meiosis results in daughter cells with half the number of chromosomes of the parent cell. b. Meiosis involves two rounds of a sequential series of steps (meiosis I and meiosis II). *IST-1.G.1 Mitosis and meiosis are similar in the way chromosomes segregate but differ in the number of cells produced and the genetic content of the daughter cells.* *IST-1.H.1 Separation of the homologous chromosomes in meiosis I ensures that each gamete receives a haploid (1n) set of chromosomes that comprises both maternal and paternal chromosomes.* *IST-1.H.2 During meiosis I, homologous chromatids exchange genetic material via a process called "crossing over" (recombination), which increases genetic diversity among the resultant gametes.* *IST-1.H.3 Sexual reproduction in eukaryotes involving gamete formation—including crossing over, the random assortment of chromosomes during meiosis, and subsequent fertilization of gametes—serves to increase variation.* *EVO-2.A.1 DNA and RNA are carriers of genetic information.* *EVO-2.A.2 Ribosomes are found in all forms of life.* *EVO-2.A.3 Major features of the genetic code are shared by all modern living systems.* *EVO-2.A.4 Core metabolic pathways are conserved across all currently recognized domains.* *IST-1.I.1 Mendel's laws of segregation and independent assortment can be applied to genes that are on different chromosomes.* *IST-1.I.2 Fertilization involves the fusion of two haploid gametes, restoring the diploid number of chromosomes and increasing genetic variation in populations by creating new combinations of alleles in the zygote— a. Rules of probability can be applied to analyze passage of single-gene traits from parent to offspring. b. The pattern of inheritance (monohybrid, dihybrid, sex-linked, and genetically linked genes) can often be predicted from data, including pedigree, that give the parent genotype/phenotype and the offspring genotypes/phenotypes.*		

RELEVANT EQUATION

Laws of Probability—

If A and B are mutually exclusive, then:

$P(A \text{ or } B) = P(A) + P(B)$

If A and B are independent, then:

$P(A \text{ and } B) = P(A) \times P(B)$

IST-1.J.1 Patterns of inheritance of many traits do not follow ratios predicted by Mendel's laws and can be identified by quantitative analysis, where observed phenotypic ratios statistically differ from the predicted ratios— a. Genes that are adjacent and close to one another on the same chromosome may appear to be genetically linked; the probability that genetically linked genes will segregate as a unit can be used to calculate the map distance between them.
IST-1.J.2 Some traits are determined by genes on sex chromosomes and are known as sexlinked traits. The pattern of inheritance of sex-linked traits can often be predicted from data, including pedigree, indicating the parent genotype/phenotype and the offspring genotypes/phenotypes.
IST-1.J.3 Many traits are the product of multiple genes and/or physiological processes acting in combination; these traits therefore do not segregate in Mendelian patterns.
IST-1.J.4 Some traits result from non-nuclear inheritance— a. Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules. b. In animals, mitochondria are transmitted by the egg and not by sperm; as such, traits determined by the mitochondrial DNA are maternally inherited. c. In plants, mitochondria and chloroplasts are transmitted in the ovule and not in the pollen; as such, mitochondria-determined and chloroplast-determined traits are maternally inherited.
SYI-3.B.1 Environmental factors influence gene expression and can lead to phenotypic plasticity. Phenotypic plasticity occurs when individuals with the same genotype exhibit different phenotypes in different environments.
SYI-3.C.1 Segregation, independent assortment of chromosomes, and fertilization result in genetic variation in populations.
SYI-3.C.2 The chromosomal basis of inheritance provides an understanding of the pattern of transmission of genes from parent to offspring.
SYI-3.C.3 Certain human genetic disorders can be attributed to the inheritance of a single affected or mutated allele or specific chromosomal changes, such as nondisjunction.

Unit Duration:

<table>
<tr><th colspan="3"> 
Unit [6]: [Gene Expression and Regulation 12-16%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 3 Info Storage and Transmission IST How does gene regulation relate to the continuity of life? How is a species' genetic information diversified from generation to generation?

9-12.LS1.A.1
9-12.LS3.B.2
9-12.LS3.B.3</td><td></td><td></td></tr>
<tr><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td></td><td>IST-1 Heritable information provides for continuity of life.
IST-1 Heritable information provides for continuity of life.
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IST-1 Heritable information provides for continuity of life.
IST-2 Differences in the expression of genes account for some of the phenotypic differences between organisms.
IST-2 Differences in the expression of genes account for some of the phenotypic differences between organisms.
IST-4 The processing of genetic information is imperfect and is a source of genetic variation.
IST-1 Heritable information provides for continuity of life.</td><td>IST-1.K Describe the structures involved in passing hereditary information from one generation to the next.
IST-1.L Describe the characteristics of DNA that allow it to be used as the hereditary material.
IST-1.M Describe the mechanisms by which genetic information is copied for transmission between generations.
IST-1.N Describe the mechanisms by which genetic information flows from DNA to RNA to protein.
IST-1.0 Explain how the phenotype of an organism is determined by its genotype.
IST-2.A Describe the types of interactions that regulate gene expression.
IST-2.B Explain how the location of regulatory sequences relates to their function.</td></tr>
</table>

		IST-2.C Explain how the binding of transcription factors to promoter regions affects gene expression and/or the phenotype of the organism. *IST-2.D Explain the connection between the regulation of gene expression and phenotypic differences in cells and organisms.* *IST-2.E Describe the various types of mutation.* *IST-4.A Explain how changes in genotype may result in changes in phenotype.* *IST-4.B Explain how alterations in DNA sequences contribute to variation that can be subject to natural selection.* *IST-1.P Explain the use of genetic engineering techniques in analyzing or manipulating DNA.*
Essential Knowledge		
IST-1.K.1 DNA, and in some cases RNA, is the primary source of heritable information. *IST-1.K.2 Genetic information is transmitted from one generation to the next through DNA or RNA— a. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules. b. Prokaryotic organisms typically have circular chromosomes, while eukaryotic organisms typically have multiple linear chromosomes.* *IST-1.K.3 Prokaryotes and eukaryotes can contain plasmids, which are small extrachromosomal, double-stranded, circular DNA molecules.* *IST-1.L.1 DNA, and sometimes RNA, exhibits specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G)— a. Purines (G and A) have a double ring structure. b. Pyrimidines (C, T, and U) have a single ring structure.* *IST-1.M.1 DNA replication ensures continuity of hereditary information— a. DNA is synthesized in the 5' to 3' direction. b. Replication is a semiconservative process—that is, one strand of DNA serves as the template for a new strand of complementary DNA. c. Helicase unwinds the DNA strands. d. Topoisomerase relaxes supercoiling in front of the replication fork. e. DNA polymerase requires RNA primers to initiate DNA synthesis. f. DNA polymerase synthesizes new strands of DNA continuously on the leading strand and discontinuously on the lagging strand. g. Ligase joins the fragments on the lagging strand.* *IST-1.N.1 The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function— a. mRNA molecules carry information from DNA to the ribosome. b. Distinct tRNA molecules bind specific amino acids and have anticodon sequences that base pair with the mRNA. tRNA is recruited*		

to the ribosome during translation to generate the primary peptide sequence based on the mRNA sequence. c. rRNA molecules are functional building blocks of ribosomes.
IST-1.N.2 Genetic information flows from a sequence of nucleotides in DNA to a sequence of bases in an mRNA molecule to a sequence of amino acids in a protein.
IST-1.N.3 RNA polymerases use a single template strand of DNA to direct the inclusion of bases in the newly formed RNA molecule. This process is known as transcription.
IST-1.N.4 The DNA strand acting as the template strand is also referred to as the noncoding strand, minus strand, or antisense strand. Selection of which DNA strand serves as the template strand depends on the gene being transcribed.
IST-1.N.5 The enzyme RNA polymerase synthesizes mRNA molecules in the 5' to 3' direction by reading the template DNA strand in the 3' to 5' direction.
IST-1.N.6 In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications— a. Addition of a poly-A tail. b. Addition of a GTP cap. c. Excision of introns and splicing and retention of exons. d. Excision of introns and splicing and retention of exons can generate different versions of the resulting mRNA molecule; this is known as alternative splicing.
IST-1.O.1 Translation of the mRNA to generate a polypeptide occurs on ribosomes that are present in the cytoplasm of both prokaryotic and eukaryotic cells and on the rough endoplasmic reticulum of eukaryotic cells.
IST-1.O.2 In prokaryotic organisms, translation of the mRNA molecule occurs while it is being transcribed.
IST-1.O.3 Translation involves energy and many sequential steps, including initiation, elongation, and termination.
IST-1.O.4 The salient features of translation include— a. Translation is initiated when the rRNA in the ribosome interacts with the mRNA at the start codon. b. The sequence of nucleotides on the mRNA is read in triplets called codons. c. Each codon encodes a specific amino acid, which can be deduced by using a genetic code chart. Many amino acids are encoded by more than one codon. d. Nearly all living organisms use the same genetic code, which is evidence for the common ancestry of all living organisms. e. tRNA brings the correct amino acid to the correct place specified by the codon on the mRNA. f. The amino acid is transferred to the growing polypeptide chain. g. The process continues along the mRNA until a stop codon is reached. h. The process terminates by release of the newly synthesized polypeptide/protein.
IST-1.O.5 Genetic information in retroviruses is a special case and has an alternate flow of information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny.
IST-2.A.1 Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription. IST-2.A.2 Epigenetic changes can affect gene expression through reversible modifications of DNA or histones. IST-2.A.3 The phenotype of a cell or organism is determined by the combination of genes that are expressed and the levels at which they are expressed— a. Observable cell differentiation results from the expression of genes for tissue specific proteins. b. Induction of transcription factors during development results in sequential gene expression.

IST-2.B.1 Both prokaryotes and eukaryotes have groups of genes that are coordinated— a. In prokaryotes, groups of genes called operons are transcribed in a single mRNA molecule. The lac operon is an example of an inducible promoter. b. In eukaryotes, groups of genes may be influenced by the same transcription factors to coordinately regulate expression.
IST-2.C.1 Promoters are DNA sequences upstream of the transcription start site where RNA polymerase and transcription factors bind to initiate transcription.
IST-2.C.2 Negative regulatory molecules inhibit gene expression by binding to DNA and blocking transcription.
IST-2.D.1 Gene regulation results in differential gene expression and influences cell products and function. IST-2.D.2 Certain small RNA molecules have roles in regulating gene expression.
IST-2.E.1 Changes in genotype can result in changes in phenotype— a. The function and amount of gene products determine the phenotype of organisms. i. The normal function of the genes and gene products collectively comprises the normal function of organisms. ii. Disruptions in genes and gene products cause new phenotypes.
IST-2.E.2 Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype. DNA mutations can be positive, negative, or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein.
IST-4.A.1 Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random mutations in the DNA— a. Whether a mutation is detrimental, beneficial, or neutral depends on the environmental context. b. Mutations are the primary source of genetic variation.
IST-4.A.2 Errors in mitosis or meiosis can result in changes in phenotype— a. Changes in chromosome number often result in new phenotypes, including sterility caused by triploidy, and increased vigor of other polyploids. b. Changes in chromosome number often result in human disorders with developmental limitations, including Down syndrome/ Trisomy 21 and Turner syndrome.
IST-4.B.1 Changes in genotype may affect phenotypes that are subject to natural selection. Genetic changes that enhance survival and reproduction can be selected for by environmental conditions— a. The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer of DNA), and transposition (movement of DNA segments within and between DNA molecules) increase variation. b. Related viruses can combine/recombine genetic information if they infect the same host cell. c. Reproduction processes that increase genetic variation are evolutionarily conserved and are shared by various organisms.
IST-1.P.1 Genetic engineering techniques can be used to analyze and manipulate DNA and RNA— a. Electrophoresis separates molecules according to size and charge. b. During polymerase chain reaction (PCR), c. Bacterial transformation introduces DNA into bacterial cells. d. DNA sequencing determines the order of nucleotides in a DNA molecule.

Unit Duration:

<table>
<tr><th colspan="3">Unit [7]: [Natural Selection 13-20%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 1 Evolution EVO
What conditions in a population make it more or less likely to evolve? Scientifically defend the theory of evolution.
BIG IDEA 4 Systems Interactions SYI
How does species interaction encourage or slow changes in species?

9-12.LS4.C.1
9-12.LS4.B.1
9-12.LS4.B.2
9-12.LS4.A.1
9-12.LS4.A.2</td><td colspan="2"></td></tr>
<tr><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td></td><td>EVO-1 Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.
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EVO-1 Evolution is characterized by a change in the genetic makeup of a population over time and is supported by multiple lines of evidence.</td><td>EVO-1.C Describe the causes of natural selection.
EVO-1.D Explain how natural selection affects populations.
EVO-1.E Describe the importance of phenotypic variation in a population.
EVO-1.F Explain how humans can affect diversity within a population.
EVO-1.G Explain the relationship between changes in the environment and evolutionary changes in the population.
EVO-1.H Explain how random occurrences affect the genetic makeup of a population.
EVO-1.I Describe the role of random processes in the evolution of specific populations.

EVO-1.J Describe the change in the genetic makeup of a population over time.</td></tr>
</table>

	EVO-2 Organisms are linked by lines of descent from common ancestry. *EVO-2 Organisms are linked by lines of descent from common ancestry.* *EVO-3 Life continues to evolve within a changing environment.* *EVO-3 Life continues to evolve within a changing environment.* *EVO-3 Life continues to evolve within a changing environment.* *EVO-3 Life continues to evolve within a changing environment.* *SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment.* *SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment.*	EVO-1.K Describe the conditions under which allele and genotype frequencies will change in populations. EVO-1.L Explain the impacts on the population if any of the conditions of HardyWeinberg are not met. EVO-1.M Describe the types of data that provide evidence for evolution. EVO-1.N Explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time. EVO-2.B Describe the fundamental molecular and cellular features shared across all domains of life, which provide evidence of common ancestry. EVO-2.C Describe structural and functional evidence on cellular and molecular levels that provides evidence for the common ancestry of all eukaryotes. EVO-3.A Explain how evolution is an ongoing process in all living organisms. EVO-3.B Describe the types of evidence that can be used to infer an evolutionary relationship. EVO-3.C Explain how a phylogenetic tree and/or cladogram can be used to infer evolutionary relatedness. EVO-3.D Describe the conditions under which new species may arise. EVO-3.E Describe the rate of evolution and speciation under different ecological conditions.

		EVO-3.F Explain the processes and mechanisms that drive speciation. EVO-3.G Describe factors that lead to the extinction of a population. EVO-3.H Explain how the risk of extinction is affected by changes in the environment. EVO-3.I Explain species diversity in an ecosystem as a function of speciation and extinction rates. EVO-3.J Explain how extinction can make new environments available for adaptive radiation. SYI-3.D Explain how the genetic diversity of a species or population affects its ability to withstand environmental pressures. SYI-3.E Describe the scientific evidence that provides support for models of the origin of life on Earth.
Essential Knowledge		
EVO-1.C.1 Natural selection is a major mechanism of evolution. *EVO-1.C.2 According to Darwin's theory of natural selection, competition for limited resources results in differential survival. Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.* *EVO-1.D.1 Evolutionary fitness is measured by reproductive success.* *EVO-1.D.2 Biotic and abiotic environments can be more or less stable/fluctuating, and this affects the rate and direction of evolution; different genetic variations can be selected in each generation.* *EVO-1.E.1 Natural selection acts on phenotypic variations in populations.* *EVO-1.E.2 Environments change and apply selective pressures to populations.* *EVO-1.E.3 Some phenotypic variations significantly increase or decrease fitness of the organism in particular environments.* *EVO-1.F.1 Through artificial selection, humans affect variation in other species.* *EVO-1.G.1 Convergent evolution occurs when similar selective pressures result in similar phenotypic adaptations in different populations or species.*		

EVO-1.H.1 Evolution is also driven by random occurrences— a. Mutation is a random process that contributes to evolution. b. Genetic drift is a nonselective process occurring in small populations— i. Bottlenecks. ii. Founder effect. c. Migration/gene flow can drive evolution.
EVO-1.I.1 Reduction of genetic variation within a given population can increase the differences between populations of the same species.
EVO-1.J.1 Mutation results in genetic variation, which provides phenotypes on which natural selection acts.
EVO-1.K.1 Hardy-Weinberg is a model for describing and predicting allele frequencies in a non evolving population. Conditions for a population or an allele to be in Hardy-Weinberg equilibrium are—(1) a large population size, (2) absence of migration, (3) no net mutations, (4) random mating, and (5) absence of selection. These conditions are seldom met, but they provide a valuable null hypothesis.
EVO-1.K.2 Allele frequencies in a population can be calculated from genotype frequencies.

RELEVANT EQUATION

Hardy-Weinberg Equation—

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

where:

p = frequency of allele 1 in the population

q = frequency of allele 2 in the population

EVO-1.L.1 Changes in allele frequencies provide evidence for the occurrence of evolution in a population.
EVO-1.L.2 Small populations are more susceptible to random environmental impact than large populations.
EVO-1.M.1 Evolution is supported by scientific evidence from many disciplines (geographical, geological, physical, biochemical, and mathematical data).
EVO-1.N.1 Molecular, morphological, and genetic evidence from extant and extinct organisms adds to our understanding of evolution— a. Fossils can be dated by a variety of methods. These include: i. The age of the rocks where a fossil is found ii. The rate of decay of isotopes including carbon-14 iii. Geographical data b. Morphological homologies, including vestigial structures, represent features shared by common ancestry.
EVO-1.N.2 A comparison of DNA nucleotide sequences and/or protein amino acid sequences provides evidence for evolution and common ancestry.
EVO-2.B.1 Many fundamental molecular and cellular features and processes are conserved across organisms.
EVO-2.B.2 Structural and functional evidence supports the relatedness of organisms in all domains.
EVO-2.C.1 Structural evidence indicates common ancestry of all eukaryotes— a. Membrane-bound organelles b. Linear chromosomes c. Genes that contain introns
EVO-3.A.1 Populations of organisms continue to evolve.

EVO-3.A.2 All species have evolved and continue to evolve— a. Genomic changes over time. b. Continuous change in the fossil record. c. Evolution of resistance to antibiotics, pesticides, herbicides, or chemotherapy drugs. d. Pathogens evolve and cause emergent diseases.
EVO-3.B.1 Phylogenetic trees and cladograms show evolutionary relationships among lineages— a. Phylogenetic trees and cladograms both show relationships between lineages, but phylogenetic trees show the amount of change over time calibrated by fossils or a molecular clock. b. Traits that are either gained or lost during evolution can be used to construct phylogenetic trees and cladograms— i. Shared characters are present in more than one lineage. ii. Shared, derived characters indicate common ancestry and are informative for the construction of phylogenetic trees and cladograms. iii. The out-group represents the lineage that is least closely related to the remainder of the organisms in the phylogenetic tree or cladogram. c. Molecular data typically provide more accurate and reliable evidence than morphological traits in the construction of phylogenetic trees or cladograms.
EVO-3.C.1 Phylogenetic trees and cladograms can be used to illustrate speciation that has occurred. The nodes on a tree represent the most recent common ancestor of any two groups or lineages.
EVO-3.C.2 Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species and from DNA and protein sequence similarities.
EVO-3.C.3 Phylogenetic trees and cladograms represent hypotheses and are constantly being revised, based on evidence.
EVO-3.D.1 Speciation may occur when two populations become reproductively isolated from each other.
EVO-3.D.2 The biological species concept provides a commonly used definition of species for sexually reproducing organisms. It states that species can be defined as a group capable of interbreeding and exchanging genetic information to produce viable, fertile offspring.
EVO-3.E.1 Punctuated equilibrium is when evolution occurs rapidly after a long period of stasis. Gradualism is when evolution occurs slowly over hundreds of thousands or millions of years.
EVO-3.E.2 Divergent evolution occurs when adaptation to new habitats results in phenotypic diversification. Speciation rates can be especially rapid during times of adaptive radiation as new habitats become available.
EVO-3.F.1 Speciation results in diversity of life forms.
EVO-3.F.2 Speciation may be sympatric or allopatric.
EVO-3.F.3 Various prezygotic and postzygotic mechanisms can maintain reproductive isolation and prevent gene flow between populations.
EVO-3.G.1 Extinctions have occurred throughout Earth's history.
EVO-3.G.2 Extinction rates can be rapid during times of ecological stress.
EVO-3.H.1 Human activity can drive changes in ecosystems that cause extinctions.
EVO-3.I.1 The amount of diversity in an ecosystem can be determined by the rate of speciation and the rate of extinction.
EVO-3.J.1 Extinction provides newly available niches that can then be exploited by different species.
SYI-3.D.1 The level of variation in a population affects population dynamics— a. Population ability to respond to changes in the environment is influenced by genetic diversity. Species and populations with little genetic diversity are at risk of decline or extinction. b. Genetically diverse populations are more resilient to

environmental perturbation because they are more likely to contain individuals who can withstand the environmental pressure. c. Alleles that are adaptive in one environmental condition may be deleterious in another because of different selective pressures. *SYI-3.E.1 Several hypotheses about the origin of life on Earth are supported with scientific evidence— a. Geological evidence provides support for models of the origin of life on Earth. i. Earth formed approximately 4.6 billion years ago (bya). The environment was too hostile for life until 3.9 bya, and the earliest fossil evidence for life dates to 3.5 bya. Taken together, this evidence provides a plausible range of dates when the origin of life could have occurred. b. There are several models about the origin of life on Earth— i. Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized because of the presence of available free energy and the absence of a significant quantity of atmospheric oxygen (O2). ii. Organic molecules could have been transported to Earth by a meteorite or other celestial event. c. Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life— i. Organic molecules/monomers served as building blocks for the formation of more complex molecules, including amino acids and nucleotides. ii. The joining of these monomers produced polymers with the ability to replicate, store, and transfer information.* *SYI-3.E.2 The RNA World Hypothesis proposes that RNA could have been the earliest genetic material.*
Unit Duration:

<table>
<tr><th colspan="3">Unit [8]: [Ecology 10-15%]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">BIG IDEA 1 Evolution EVO
How does diversity among and between species in a biological system affect the evolution of species within the system?
BIG IDEA 2 Energetics ENE
How does the acquisition of energy relate to the health of a biological system? How do communities and ecosystems change, for better or worse, due to biological disruption?
BIG IDEA 3 Info Storage and Transmission IST
How does a disruption of a biological system affect genetic information storage and transmission?
BIG IDEA 4 Systems Interactions SYI
How do species interactions affect the survival of an ecosystem?

9-12.LS2.A.1
9-12.LS2.B.2
9-12.LS2.C.1
9-12.LS2.C.2
9-12.LS4.C.2
9-12.LS4.C.3</td><td colspan="2"></td></tr>
<tr><td>Enduring Understandings</td><td>Learning Objectives</td></tr>
<tr><td></td><td>ENE-3 Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.
IST-5 Transmission of information results in changes within and between biological systems.
ENE-1 The highly complex organization of living systems requires constant input of energy and the exchange of macromolecules.
SYI-1 Living systems are organized in a hierarchy of structural levels that interact.
SYI-1 Living systems are organized in a hierarchy of structural levels that interact.
ENE-4 Communities and ecosystems change on the basis of interactions among populations and disruptions to the environment.</td><td>ENE-3.D Explain how the behavioral and/or physiological response of an organism is related to changes in internal or external environment.
IST-5.A Explain how the behavioral responses of organisms affect their overall fitness and may contribute to the success of the population.
ENE-1.M Describe the strategies organisms use to acquire and use energy.
ENE-1.N Explain how changes in energy availability affect populations and ecosystems.
ENE-1.O Explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.
SYI-1.G Describe factors that influence growth dynamics of populations.
SYI-1.H Explain how the density of a population affects and is determined by resource availability in the environment.</td></tr>
</table>

	SYI-3 Naturally occurring diversity among and between components within biological systems affects interactions with the environment. *EVO-1 Evolution is characterized by change in the genetic make-up of a population over time and is supported by multiple lines of evidence.* *SYI-2 Competition and cooperation are important aspects of biological systems.*	ENE-4.A Describe the structure of a community according to its species composition and diversity. ENE-4.B Explain how interactions within and among populations influence community structure. ENE-4.C Explain how community structure is related to energy availability in the environment. SYI-3.F Describe the relationship between ecosystem diversity and its resilience to changes in the environment. SYI-3.G Explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure. EVO-1.O Explain the interaction between the environment and random or preexisting variations in populations. SYI-2.A Explain how invasive species affect ecosystem dynamics. SYI-2.B Describe human activities that lead to changes in ecosystem structure and/ or dynamics. SYI-2.C Explain how geological and meteorological activity leads to changes in ecosystem structure and/or dynamics.
Essential Knowledge		
ENE-3.D.1 Organisms respond to changes in their environment through behavioral and physiological mechanisms. *ENE-3.D.2 Organisms exchange information with one another in response to internal changes and external cues, which can change behavior.* *IST-5.A.1 Individuals can act on information and communicate it to others.*		

IST-5.A.2 Communication occurs through various mechanisms— a. Organisms have a variety of signaling behaviors that produce changes in the behavior of other organisms and can result in differential reproductive success. b. Animals use visual, audible, tactile, electrical, and chemical signals to indicate dominance, find food, establish territory, and ensure reproductive success.
IST-5.A.3 Responses to information and communication of information are vital to natural selection and evolution— a. Natural selection favors innate and learned behaviors that increase survival and reproductive fitness. b. Cooperative behavior tends to increase the fitness of the individual and the survival of the population.
ENE-1.M.1 Organisms use energy to maintain organization, grow, and reproduce— a. Organisms use different strategies to regulate body temperature and metabolism. i. Endotherms use thermal energy generated by metabolism to maintain homeostatic body temperatures. ii. Ectotherms lack efficient internal mechanisms for maintaining body temperature, though they may regulate their temperature behaviorally by moving into the sun or shade or by aggregating with other individuals. b. DIfferent organisms use various reproductive strategies in response to energy availability. c. There is a relationship between metabolic rate per unit body mass and the size of multicellular organisms—generally, the smaller the organism, the higher the metabolic rate. d. A net gain in energy results in energy storage or the growth of an organism. e. A net loss of energy results in loss of mass and, ultimately, the death of an organism.
ENE-1.N.1 Changes in energy availability can result in changes in population size.
ENE.1.N.2 Changes in energy availability can result in disruptions to an ecosystem— a. A change in energy resources such as sunlight can affect the number and size of the trophic levels. b. A change in the producer level can affect the number and size of other trophic levels.
ENE-1.O.1 Autotrophs capture energy from physical or chemical sources in the environment— a. Photosynthetic organisms capture energy present in sunlight. b. Chemosynthetic organisms capture energy from small inorganic molecules present in their environment, and this process can occur in the absence of oxygen.
ENE-1. O.2 Heterotrophs capture energy present in carbon compounds produced by other organisms. a. Heterotrophs may metabolize carbohydrates, lipids, and proteins as sources of energy by hydrolysis.
SYI-1.G.1 a. Populations comprise individual organisms that interact with one another and with the environment in complex ways.
SYI-1.G.2 Many adaptations in organisms are related to obtaining and using energy and matter in a particular environment— Population growth dynamics depend on a number of factors.

RELEVANT EQUATION

Population Growth—

$$\frac{dN}{dt} = B - D$$

where:

dt = chage in time

B = birth rate

D = death rate

N = population size

i. Reproduction without constraints results in the exponential growth of a population.

RELEVANT EQUATION

Exponential Growth—

$$\frac{dN}{dt} = r_{max} N$$

where:

dt = change in time

N = population size

r_{max} = maximum per capita growth rate of population

SYI-1.H.1 A population can produce a density of individuals that exceeds the system's resource availability.

SYI-1.H.2 As limits to growth due to density-dependent and density-independent factors are imposed, a logistic growth model generally ensues.

ENE-4.A.1 The structure of a community is measured and described in terms of species composition and species diversity.

RELEVANT EQUATION

Simpson's Diversity Index—

$$\text{Diversity Index} = 1 - \sum\left(\frac{n}{N}\right)^2$$

n = the total number of organisms of a particular species

N = total number of organisms of all species

ENE-4.B.1 Communities change over time depending on interactions between populations.
ENE-4.B.2 Interactions among populations determine how they access energy and matter within a community.
ENE-4.B.3 Relationships among interacting populations can be characterized by positive and negative effects and can be modeled. Examples include predator/prey interactions, trophic cascades, and niche partitioning.
ENE-4.B.4 Competition, predation, and symbioses, including parasitism, mutualism, and commensalism, can drive population dynamics.
ENE-4.C.1 Cooperation or coordination between organisms, populations, and species can result in enhanced movement of, or access to, matter and energy.
SYI-3.F.1 Natural and artificial ecosystems with fewer component parts and with little diversity among the parts are often less resilient to changes in the environment.
SYI-3.F.2 Keystone species, producers, and essential abiotic and biotic factors contribute to maintaining the diversity of an ecosystem.
SYI-3.G.1 The diversity of species within an ecosystem may influence the organization of the ecosystem.
SYI-3.G.2 The effects of keystone species on the ecosystem are disproportionate relative to their abundance in the ecosystem, and when they are removed from the ecosystem, the ecosystem often collapses.
EVO-1.O.1 An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.
EVO-1.O.2 Mutations are random and are not directed by specific environmental pressures.
SYI-2.A.1 The intentional or unintentional introduction of an invasive species can allow the species to exploit a new niche free of predators or competitors or to outcompete other organisms for resources.
SYI-2.A.2 The availability of resources can result in uncontrolled population growth and ecological changes.
SYI-2.B.1 The distribution of local and global ecosystems changes over time.

SYI-2.B.2 Human impact accelerates change at local and global levels— a. The introduction of new diseases can devastate native species. b. Habitat change can occur because of human activity. *SYI-2.C.1 Geological and meteorological events affect habitat change and ecosystem distribution. Biogeographical studies illustrate these changes.*
Unit Duration:

Standard: 9-12.LS1.C.3			
Topic: Chemistry of Life			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules and apply it to a real-world situation. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification		

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	Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.A.2			
Topic: Cell Structure and Function			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms and apply it to a real-world situation. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient **uptake, water delivery, and organism movement in response to stimuli.]**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.] **The student exhibits no major errors or omissions.**		

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	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.C.1		
Topic: Cellular Energetics		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy and apply it to a real-world situation. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.]	**Sample Activities**
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:**	

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	Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.C.2		
Topic: Cellular Energetics		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**

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	Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy and apply it to a real-world situation. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: 9-12.LS2.B.1			
Topic: Cellular Energetics			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur and apply it to a real-world situation. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of		

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	environmental conditions can include the availability of sunlight or oxygen.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS2.B.3			
Topic: Cellular Energetics			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere and can apply it to a real-world situation. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]		

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	The student exhibits no major errors or omissions.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.A.3		
Topic: Cell Communication and the Cell Cycle		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis and apply it to a real-world situation. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.]	**Sample Activities**
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

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Score 3.0	**The student:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.B.1		
Topic: Cell Communication and the Cell Cycle		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms and apply	**Sample Activities**

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	it to a real world situation. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents. **The student exhibits no major errors or omissions.**		
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Standard: 9-12.LS3.B.3			
Topic: Heredity			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors and apply it to a real-world situation. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs. **The student exhibits no major errors or omissions.**		
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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS3.A.1			
Topic: Heredity			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction and apply it to a real-world situation.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS1.A.1			
Topic: Gene Expression and Regulation			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells and apply it to a real-world situation. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS3.B.2			
Topic: Gene Expression and Regulation			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism and apply it to a real-world situation. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of		

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	the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS3.B.3		
Topic: Gene Expression and Regulation		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors and apply it to a real-world situation. [Clarification	**Sample Activities**

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	Statement: Emphasis is on using data to support arguments for the way variation occurs.		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.A.1
Topic: Evolution

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Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence and apply it to a real-world situation. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean written report, oral discussion, etc.)		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.) **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common		

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	ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.C.1			
Topic: Natural Selection			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct an explanation based on evidence for how natural selection leads to adaptation of populations and apply it to a real-world situation. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

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Score 3.0	**The student:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.B.1
Topic: Natural Selection

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Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexualreproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.)		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexualreproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.) **The student exhibits no major errors or omissions.**		

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	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexualreproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.B.2		
Topic: Natural Selection		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**

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	Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tends to increase in proportion to organisms lacking this trait. [ClarificationStatement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tends to increase in proportion to organisms lacking this trait. [ClarificationStatement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tends to increase in proportion to organisms lacking this trait. [ClarificationStatement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: 9-12.LS4.A.1			
Topic: Natural Selection			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.) **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common		

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	ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.A.2			
Topic: Natural Selection			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.[Clarification Statement: Emphasis is on inferring general patterns of relatedness		

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	among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS2.A.1		
Topic: Ecology		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses,competition) and disease. Examples of abiotic	**Sample Activities**

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	factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses,competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses,competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS2.B.2			
Topic: Ecology			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem.[Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one trophic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem.[Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one trophic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem.[Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one trophic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS2.C.1			
Topic: Ecology			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement:Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or aseasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while		

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	conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement:Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or aseasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement:Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or aseasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS2.C.2		
Topic: Ecology		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**

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	Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement:Examples of solutions may include captive breeding programs,habitat restoration, pollution mitigation, energy conservation,agriculture and mining programs, and ecotourism.]		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement:Examples of solutions may include captive breeding programs,habitat restoration, pollution mitigation, energy conservation,agriculture and mining programs, and ecotourism.] **The student exhibits no major errors or omissions.**		
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard: 9-12.LS4.C.2			
Topic: Ecology			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
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	fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard: 9-12.LS4.C.3			
Topic: Ecology			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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AP Chemistry ***Course Overview***	
Grade level(s):11/12	**Credits earned:** 0.5 credits per semester (additional 0.5 credit for second semester lab)
Course Rationale:*The AP Chemistry course provides students with a college-level foundation to support future advanced coursework in chemistry.*	**Course Description:** *Students cultivate their understanding of chemistry through inquiry-based investigations, as they explore content such as: atomic structure, intermolecular forces and bonding, chemical reactions, kinetics, thermodynamics, and equilibrium.*
Transfer Goals/Big Ideas	
● **Asking Questions and Defining Problems** ● **Developing and using models** ● **Planning and carrying out investigations** ● **Analyzing and interpreting data** ● **Using mathematics and computational thinking** ● **Constructing explanations and designing solutions** ● **Engaging in an argument from evidence** ● **Obtaining, evaluating, and communication information**	
Priority Missouri Learning Standards/National Standards	
[5-10 skills that every student must master] **9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** **9-12.PS1.A.2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.**	

9-12.PS1.A.3 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials (i.e., metals, ionic (ceramics), and polymers).

9-12.PS1.A.4 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.

9-12.PS1.A.5 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

9-12.PS1.B.1 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

9-12.PS1.B.2 Refine the design of a chemical system by specifying a change in conditions that would alter the amount of products at equilibrium.

9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Unit 1: Science Practices
Proper Experimental Procedure

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td>

- **9-12.PS1.A.4**

I</td><td colspan="2">BIG IDEA 5: SCIENCE PRACTICES
As a science, chemistry requires experimentation to collect viable data that can support or refute scientific claims. All experimentation must be done in a valid, safe way to preserve the integrity of the data as well as to protect the health of the scientist. Experimental data is the cornerstone to scientific theories and hypotheses as it provides evidence for scientific claims.</td></tr>
<tr><td></td><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>

- Scientists develop models and representations for concepts and chemical phenomena.
- Scientists follow a methodology to answer questions about the natural world.
- Scientists propose explanations that are supported by evidence.
- Argumentation is a component of the scientific process and can be conducted in a courteous manner.
- Scientists use mathematical relationships to solve problems.
- Scientists analyze and interpret models and representations to draw conclusions.

</td><td>

- How do scientists describe the components of and quantitative information from models and representations that illustrate particulate-level properties only?
- How do scientists describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic level properties?
- How do scientists identify a testable scientific question based on an observation, data, or a model?
- How do scientists formulate a hypothesis or predict the results of an experiment?
- How do scientists Identify experimental procedures that are aligned to a scientific question (which may include a sketch of a lab setup)?
- How do scientists make observations or collect data from representations of

</td></tr>
</table>

		laboratory setups or results, while attending to precision where appropriate? ● How do scientists identify or describe potential sources of experimental error? ● How do scientists explain how modifications to an experimental procedure will alter results? ● How do scientists represent chemical phenomena using appropriate graphing techniques, including correct scale and units? ● How do scientists represent chemical substances or phenomena with appropriate diagrams or models (e.g., electron configuration)? ● How do scientists represent visually the relationship between the structures and interactions across multiple levels or scales (e.g., particulate to macroscopic)? ● How do scientists explain chemical properties or phenomena (e.g., of atoms or molecules) using given chemical theories, models, and representations? ● How do scientists explain whether a model is consistent with chemical theories? ● How do scientists explain the connection between particulate-level and macroscopic properties of a substance using models and representations?

		● How do scientists explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties? ● How do scientists identify quantities needed to solve a problem from given information (e.g., text, mathematical expressions, graphs, or tables)? ● How do scientists identify an appropriate theory, definition, or mathematical relationship to solve a problem? ● How do scientists explain the relationship between variables within an equation when one variable changes? ● How do scientists identify information presented graphically to solve a problem? ● How do scientists determine a balanced chemical equation for a given chemical phenomenon? ● How do scientists calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (e.g., performing dimensional analysis and attending to significant figures)? ● What makes a claim scientific? ● How can a scientist support a claim with evidence from experimental data?

		● How can a scientist support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules? ● How can a scientist justify a claim using chemical principles or laws, or using mathematical justification? ● How do experimental results support chemical concepts, processes, or theories? ● How can potential sources of experimental error may affect the experimental results?
Learning Targets		
Students will… ● Describe models and representations, including across scales. ● Determine scientific questions and methods. ● Create representations or models of chemical phenomena. ● Develop an explanation or scientific argument. ● Solve problems using mathematical relationships. ● Analyze and interpret models and representations on a single scale or across multiple scales.		
Unit Duration:		
Ongoing		

<table>
<tr><th colspan="3">Unit 2: Atomic Structure and Properties</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.A.1
9-12.PS1.A.4
9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.

BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>The mole allows different units to be compared.
Chemical formulas identify substances by their unique combination of atoms.
Atoms and molecules can be identified by their electron distribution and energy.
The periodic table shows patterns in electronic structure and trends in atomic properties.</td><td>What is the connection between the masses of substances reacting and the actual number of particles undergoing chemical changes?
How does Avogadro’s number provide the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance?
How is expressing the mass of an individual atom or molecule in atomic mass units (amu) useful?</td></tr>
</table>

		● Is the average mass in amu of one particle (atom or molecule) or formula unit of a substance always numerically equal to the molar mass of that substance in grams? ● Is there a quantitative connection between the mass of a substance and the number of particles that the substance contains? ● How is the mass spectrum of a sample containing a single element used to determine the identity of the isotopes of that element and the relative abundance of each isotope in nature? ● How is the average atomic mass of an element estimated from the weighted average of the isotopic masses using the mass of each isotope and its relative abundance? ● When are substances composed of individual molecules, or atoms or ions held together in fixed proportions as described by a formula unit? ● What does the law of definite proportions tell us about the ratio of the masses of the constituent elements in any pure sample? ● How does a scientist write the empirical formula of a compound? ● How do pure substances differ from mixtures?

		● How is elemental analysis used to determine the relative numbers of atoms in a substance and to determine its purity? ● What is the atom composed of? ● How is Coulomb's law used to calculate the force between two charged particles? ● How are electrons in atoms and ions described by the electron configuration? ● How are the electrons described as being in "shells (energy levels)" and "subshells (sublevels)"? ● What are inner and outer electrons called? ● How are electron configurations explained by quantum mechanics, as delineated in the Aufbau principle and exemplified in the periodic table of the elements? ● How is the relative energy required to remove an electron from different subshells of an atom or ion or from the same subshell in different atoms or ions (ionization energy) estimated through a qualitative application of Coulomb's law? ● How does Coulomb's law relate the energy to the distance from the nucleus and the effective (shield) charge of the nucleus? ● How can the energies of the electrons in a given shell be measured experimentally with photoelectron spectroscopy (PES)? ● How is the position of each peak in the PES spectrum related to the energy required to

		remove an electron from the corresponding subshell? ● How is the height of each peak in the PES spectrum (ideally) proportional to the number of electrons in that subshell? ● How is the organization of the periodic table based on the recurring properties of the elements and explained by the pattern of electron configurations and the presence of completely or partially filled shells (and subshells) of electrons in atoms? ● How can trends in atomic properties within the periodic table (periodicity) be qualitatively understood through the position of the element in the periodic table, Coulomb's law, the shell model, and the concept of shielding/effective nuclear charge? These properties include: a. Ionization energy b. Atomic and ionic radii c. Electron affinity d. Electronegativity. ● How is the periodicity used to predict /estimate values of properties in the absence of data? ● How is the likelihood that two elements will form a chemical bond determined by the interactions between the valence electrons and nuclei of elements?

		● Do elements in the same column of the periodic table tend to form analogous compounds? ● How are the typical charges of atoms in ionic compounds governed by their location on the periodic table and the number of valence electrons?

Learning Targets

Students will…

- Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.
- Explain the quantitative relationship between the mass spectrum of an element and the masses of the element's isotopes
- Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance.
- Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture.
- Represent the electron configuration of an element or ions of an element using the Aufbau principle.
- Explain the relationship between the photoelectron spectrum of an atom or ion and: a. The electron configuration of the species. b. The interactions between the electrons and the nucleus.
- Explain the relationship between trends in atomic properties of elements and electronic structure and periodicity.
- Explain the relationship between trends in the reactivity of elements and periodicity.

Unit Duration:

2-3 Weeks

<table>
<tr><th colspan="3">Unit 3: Molecular and Ionic Compound Structure and Properties</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.A.2
9-12.PS1.A.3
9-12.PS1.A.4
9-12.PS4.B.1</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>Atoms or ions bond due to interactions between them, forming molecules.
Molecular compounds are arranged based on Lewis diagrams and Valence Shell Electron Pair Repulsion (VSEPR) theory.</td><td>How do electronegativity values for the representative elements change going from left to right across a period and going down a group?
When do valence electrons shared between atoms of similar electronegativity constitute a nonpolar covalent bond?
When do valence electrons shared between atoms of unequal electronegativity constitute a polar covalent bond?
Besides electronegativity, how can bond nature (ionic or covalent) be predicted?
Why In a metallic solid are the valence electrons from the metal atoms considered delocalized and not associated with any individual atom?</td></tr>
</table>

		● How is a graph of potential energy versus the distance between atoms a useful representation for describing the interactions between atoms? ● How is bond length influenced by the size of the atom and bond order (i.e. single, double, triple)? ● How can coulomb's law be used to understand the strength of interactions between cations and anions? ● Why do cations and anions in an ionic crystal arrange in a systematic, periodic 3-D array? ● What are the properties of electrons in metallic bonding? ● How do interstitial alloys Interstitial alloys form? ● How do substitutional alloys form? ● What are the established set of principles for Lewis diagrams? ● How does one consider resonance in cases where more than one equivalent Lewis structure can be constructed? ● How are the octet rule and formal charge used as criteria for determining which of several possible valid Lewis diagrams provides the best model for predicting molecular structure and properties? ● What are the limitations to the use of the Lewis structure model?

		● How is coulombic repulsion between electrons used for predicting the arrangement of electron pairs around a central atom in VSEPR theory? ● How are both Lewis diagrams and VSEPR theory used for predicting electronic and structural properties of many covalently bonded molecules and polyatomic ions? ● How are the terms “hybridization” and “hybrid atomic orbital” used to describe the arrangement of electrons around a central atom? ● How do the overlap in s and p orbitals lead to the formation of sigma and pi bonds? ● How do the overlap in s and p orbitals affect bond energies?

Learning Targets

Students will…

- Explain the relationship between the type of bonding and the properties of the elements participating in the bond.
- Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength.
- Represent an ionic solid with a particulate model that is consistent with Coulomb’s law and the properties of the constituent ions.
- Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance.
- Represent a molecule with a Lewis diagram.
- Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures.
- Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities: a. Explain structural properties of molecules. b. Explain electron properties of molecules.

Unit Duration:
3-4 Weeks

Unit 4: : Intermolecular Forces and Properties		
Standards	**Transfer Goal(s) /Big Ideas**	
9-12.PS1.A.3 **9-12.PS1.B.3**	BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales. BIG IDEA 2: STRUCTURE AND PROPERTIES Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.	
	Enduring Understandings	**Essential Questions**
	● Intermolecular forces can explain the physical properties of a material. ● Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and motion of the molecules.	● What are the causes of London dispersion forces? ● What factors increase dispersion forces? ● What factors increase the polarizability of a molecule?

	• Gas properties are explained macroscopically—using the relationships among pressure, volume, temperature, moles, gas constant—and molecularly by the motion of the gas. • Interactions between intermolecular forces influence the solubility and separation of mixtures. • Spectroscopy can determine the structure and concentration in a mixture of a chemical species.	• How does the dipole moment of a polar molecule lead to additional interactions with other chemical species? • How can the relative strength and orientation dependence of dipole-dipole and ion-dipole forces be best understood? • What is a Hydrogen bond and how does a Hydrogen bond interact? • When do Hydrogen bonds occur? • Why, In large biomolecules, do noncovalent interactions occur between different molecules or between different regions of the same large biomolecule? • How are properties of liquids and solids determined by the strengths and types of intermolecular forces present? • When a substance vaporizes, how are the vapor pressure and boiling point related to the strength of the intermolecular forces present? • How do melting points correlate with interaction strength? • How are showing multiple interacting chemical species useful in particulate-level representations? • Why do ionic solids tend to have low vapor pressures, high melting points, and high boiling points? • Why do ionic solids tend to be brittle? • When do ionic solids conduct electricity?

		● How are atoms in covalent network solids bonded together? ● What types of atoms form covalent network solids? ● Why do covalent solids have high melting points? ● What are some network solids rigid and hard, while graphite is soft? ● What are molecular solids composed of, on a chemical level? ● Why do molecular solids generally have a low melting point? ● Why don't molecular solids conduct electricity? ● What is a polymer? ● Why are metallic solids a good conductors of electricity and heat? ● Why do metallic solids tend to be malleable and ductile? ● Why are interstitial alloys less malleable and ductile? ● Why, in large biomolecules or polymers, do noncovalent interactions occur between different molecules or between different regions of the same large biomolecule? ● How are crystalline solids different from amorphous solids? ● How do scientists describe the motion of the individual particles in a solid?

		● How is the structure of a solid influenced by interparticle interactions and the ability of the particles to pack together? ● What affects the movement and collision of constituent particles in liquids? ● Why do the solid and liquid phases for a particular substance typically have similar molar volume? ● How is particle motion described in the gas phase? ● How are the frequencies of collisions and the average spacing between the particles of gas dependent on temperature, pressure, and volume? ● Why do gases have neither a definite volume nor a definite shape? ● How are the macroscopic properties of ideal gases related through the ideal gas law? ● In a sample containing a mixture of ideal gases, how is the pressure exerted by each component (the partial pressure) related to the pressure exerted by the other components? ● How is the total pressure of a mixture of ideal gases calculated? ● How are graphical representations of the relationships between P, V, T, and n are useful in describing gas behavior?

		● How does kinetic molecular theory (KMT) explain the macroscopic properties of gases? ● What does a Maxwell-Boltzmann distribution describe? ● How is the motion of the particles in a sample of matter described? ● How is the average kinetic energy of a particle related to its average velocity? ● How is the Kelvin temperature of a sample of matter related to the average kinetic energy of the particles in the sample? ● Why do real gases deviate from the ideal gas law? ● Under what conditions do real gases deviate from ideal gases? ● Can solutions (sometimes called homogeneous mixtures) be solids, liquids, or gases? ● How do the macroscopic properties of homogeneous mixtures differ from the macroscopic properties of a heterogeneous mixture. ● How is solution composition expressed? ● How do particulate representations of solutions communicate the structure and properties of solutions? ● How can the components of a liquid solution be separated?

		● How is chromatography used to separate the components of a mixture? ● How is distillation used to separate the components of a mixture? ● When are substances miscible or soluble in one another? ● How are differences in absorption or emission of photons in different spectral regions related to the different types of molecular motion or electronic transition? ● What happens to the energy of the species when a photon is absorbed (or emitted) by an atom or molecule? ● How is the wavelength of the electromagnetic wave related to its frequency? ● How is the energy of a photon related to the frequency of the electromagnetic wave? ● How does the Beer-Lambert law relate the absorption of light by a solution to the concentration of the solution? ● What does the molar absorptivity of a solution describe? ● In the Beer-Lambert law, what are length b and concentration c are proportional to? ● When the path length and wavelength of light are held constant, how are absorbance and concentration of absorbing molecules or ions related?

Learning Targets

Students will…

- Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when:
  - The molecules are of the same chemical species.
  - The molecules are of two different chemical species.
- Explain the relationship among the macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.
- Represent the differences between solid, liquid, and gas phases using a particulate level model.
- Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.
- Explain the relationship between the motion of particles and the macroscopic properties of gases with: a. The kinetic molecular theory (KMT). b. A particulate model. c. A graphical representation
- Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes.
- Calculate the number of solute particles, volume, or molarity of solutions.
- Using particulate models for mixtures: a. Represent interactions between components. b. Represent concentrations of components.
- Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles.
- Explain the relationship between a region of the electromagnetic spectrum and the types of molecular or electronic transitions associated with that region
- Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule.
- Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity

Unit Duration:

4 Weeks

<table>
<tr><th colspan="3"> 
Unit 5: Chemical Reactions</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.A.2
9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.

BIG IDEA 3: TRANSFORMATIONS
At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.
When a substance changes into a new substance, or when its properties change, no mass is lost or gained.
A substance can change into another substance through different processes,</td><td>What defines a physical change?
What defines a chemical change?
How can all physical and chemical processes be represented symbolically?
How do chemical equations represent chemical changes?
How is the Law of Conservation of Mass observed in a chemical equation?</td></tr>
</table>

	and the change itself can be classified by the sort of processes that produced it.	● How are balanced molecular, complete ionic, and net ionic equations used to represent a chemical reaction? ● How can balanced chemical equations in their various forms be translated into symbolic particulate representations? ● How are chemical processes classified? ● How are physical processes classified? ● When do physical processes involve the breaking of chemical bonds? ● How does one calculate the amount of product from a known reactant amount and how does one calculate the amount of reactant from a known product amount? ● What information regarding proportionality do coefficients of balanced chemical equations contain? ● How can stoichiometric calculations be combined with the ideal gas law? ● How can titrations be used to determine the concentration of an analyte in solution? ● When does the equivalence point of the titration occur? ● How is the equivalence point often indicated? ● What happens in an acid-base reaction? ● What happens in an oxidation reduction reaction ? ● How does combustion differ from other oxidation-reduction reactions?

		● How does electron transfer differ for an element that oxidizes versus an element that redoxes? ● How are oxidation numbers assigned? ● What is involved in a precipitation reaction? ● What is the definition of a Brønsted-Lowry acid? ● What is the definition of a Brønsted-Lowry base? ● How does water play an important role in many acid-base reactions? ● How can conjugate acid-base be identified and compared when an acid or base ionizes in water? ● How are half-reactions constructed for redox reactions?

Learning Targets

Students will…

- Identify evidence of chemical and physical changes in matter.
- Represent changes in matter with a balanced chemical or net ionic equation:
  - For physical changes.
  - For given information about the identity of the reactants and/or product.
  - For ions in a given chemical reaction.
- Represent a given chemical reaction or physical process with a consistent particulate model.
- Explain the relationship between macroscopic characteristics and bond interactions for: a. Chemical processes. b. Physical processes
- Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.
- Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion.

● Identify a reaction as acid-base, oxidation-reduction, or precipitation. ● Identify species as BrønstedLowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. ● Represent a balanced redox reaction equation using half-reactions.
Unit Duration:
4 Weeks

 **Unit 6: Kinetics**	
Standards	**Transfer Goal(s) /Big Ideas**
9-12.PS1.B.1	BIG IDEA 3: TRANSFORMATIONS At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events. BIG IDEA 4: ENERGY Energy has two important roles in characterizing and controlling chemical systems. The first is accounting for the distribution of energy among the components of a system and the ways that heat exchanges, chemical reactions, and phase transitions redistribute this energy. The second is in considering the enthalpic and entropic driving forces for a chemical process. These are closely related to the dynamic equilibrium present in many chemical systems and the ways in which changes in experimental conditions alter the positions of these equilibria.

	Enduring Understandings	Essential Questions
	● Some reactions happen quickly, while others happen more slowly and depend on reactant concentrations and temperature. ● There is a relationship between the speed of a reaction and the collision frequency of particle collisions. ● Many chemical reactions occur through a series of elementary reactions. These elementary reactions when combined form a chemical equation. ● The speed at which a reaction occurs can be influenced by a catalyst.	● How are the kinetics of a chemical reaction defined? ● How are the rates of change of reactant and product concentrations determined? ● What factors influence the rate of a reaction? ● What methods can be used to monitor the amounts of reactants and/or products of a reaction and to determine the rate of the reaction? ● What does the rate law express? ● What does the power of each reactant in the rate law represent? ● What does the sum of the powers of the reactant concentrations in the rate law represent? ● What is the proportionality constant in the rate law called? ● What affects the value of the rate constant? ● How does comparing initial rates of a reaction is a method to determine the order with respect to each reactant? ● How can the order of a reaction be inferred? ● If a reaction is first order with respect to a reactant being monitored, how will a plot of the natural log (ln) of the reactant concentration as a function of time appear?

		● If a reaction is second order with respect to a reactant being monitored, how will a plot of the reciprocal of the concentration of that reactant versus time appear? ● How can the slopes of the concentration versus time data for zeroth, first, and second order reactions can be used? ● Why is Half-life a critical parameter for first order reactions? ● How does Radioactive decay processes provide an important illustration of first order kinetics? ● How can the rate law of an elementary reaction be inferred? ● How often are there elementary reactions involving the simultaneous collision of three or more particles? ● What must occur for an elementary reaction to successfully produce products? ● What must happen for a successful collision to lead to a reaction? ● How can the Maxwell-Boltzmann distribution curve describe the distribution of particle energies? ● What do elementary reactions typically involve? ● What is the reaction coordinate? ● What is the energy difference between the reactants and the transition state? ● What is the purpose of the energy profile?

		● What does the Arrhenius equation describe? ● What does a reaction mechanism consist of? ● What occurs when the elementary steps combined? ● When is a reaction intermediate present? ● How can one build evidence in support of one reaction mechanism over an alternative mechanism? ● For reaction mechanisms in which each elementary step is irreversible, or in which the first step is rate limiting, how is the rate law of the reaction set? ● If the first elementary reaction is not rate limiting, how can approximations (such as steady state) be made to determine a rate law expression? ● How can knowledge of the energetics of each elementary reaction in a mechanism lead to the construction of an energy profile for a multistep reaction? ● How can a catalyst increase the rate of a reaction? ● Why, in a reaction mechanism containing a catalyst, is the net concentration of the catalyst constant? ● How do some catalysts accelerate a reaction by binding to the reactant(s)?

		● Why do some catalysts involve covalent bonding between the catalyst and the reactant(s)? ● Where do surface catalysts bond and what do they do?

Learning Targets

Students will…

- Explain the relationship between the rate of a chemical reaction and experimental parameters.
- Represent experimental data with a consistent rate law expression.
- Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.
- Represent an elementary reaction as a rate law expression using stoichiometry
- Explain the relationship between the rate of an elementary reaction and the frequency, energy, and orientation of molecular collisions.
- Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.
- Identify the components of a reaction mechanism.
- Identify the rate law for a reaction from a mechanism in which the first step is rate limiting.
- Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting.
- Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile.
- Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism.

Unit Duration:

2-3 Weeks

<table>
<tr><th colspan="3">Unit 7: Thermodynamics</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goals/Big Idea</th></tr>
<tr><td rowspan="3">9-12.PS3.B.1
9-12.PS1.A.5</td><td colspan="2">BIG IDEA 4: ENERGY
Energy has two important roles in characterizing and controlling chemical systems. The first is accounting for the distribution of energy among the components of a system and the ways that heat exchanges, chemical reactions, and phase transitions redistribute this energy. The second is in considering the enthalpic and entropic driving forces for a chemical process. These are closely related to the dynamic equilibrium present in many chemical systems and the ways in which changes in experimental conditions alter the positions of these equilibria.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Changes in a substance’s properties or change into a different substance requires an exchange of energy.
● The energy exchanged in a chemical transformation is required to break and form bonds.</td><td>● What do temperature changes in a system indicate?
● How can energy changes in a system be described?
● When a chemical reaction occurs, how can the energy of the system change?
● What happens to the energy of the system and the surroundings in an exothermic reaction?
● What happens to the energy of the system and surroundings in an endothermic reaction?
● What determines whether the formation of a solution is an exothermic or endothermic process?
● How are energy diagrams used to describe a physical or chemical process?</td></tr>
</table>

		● How does the average kinetic energy of particles in a warmer compare to those in a cooler body? ● How does the transfer of energy (also called "heat transfer" or "transfer of energy as heat") occur between particles in thermal contact? ● At thermal equilibrium, what is true about the average kinetic energy of both bodies and their temperatures? ● How is the amount of heat transferred between two bodies quantified? ● How are calorimetry experiments used to measure the transfer of heat? ● What does the first law of thermodynamics state? ● How does the specific heat capacity of a material affect the temperature change in equal masses of matter when a given amount of thermal energy is transferred to or from the samples? ● How does heating or cooling a system change the energy of the system? ● When are the specific heat capacity of a substance and the molar heat capacity used in calculations? ● What are the three main processes by which chemical systems change their energy?

		● How does the energy of a system change when a substance undergoes a phase change? ● What happens to the temperature of a pure substance during a phase change? ● How is the energy absorbed during a phase change related to the energy released during a complementary phase change in the opposite direction? ● What does the enthalpy change of a reaction give? ● What happens to chemical bonds during a chemical reaction and how do these changes change the potential energy of the system? ● How can the average energy required to break all of the bonds in the reactant molecules be estimated? ● How can the average energy released in forming the bonds in the product molecules be estimated? ● When is a reaction endothermic or exothermic? ● How are tables of standard enthalpies of formation used to calculate the standard enthalpies of reactions? ● How is the concept of “state function” used in Hess’s law?

		● When a reaction is reversed, what happens to the mathematical sign of the enthalpy change? ● When two (or more) reactions are added to obtain an overall reaction, what is done with the individual enthalpy changes of each reaction? ● What occurs when the products of a reaction are at a different temperature than their surroundings? ● For an exothermic reaction, how is thermal energy transferred? ● For an endothermic reaction, how is energy transferred?

Learning Targets

Students will…

- Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation.
- Represent a chemical or physical transformation with an energy diagram.
- Explain the relationship between the transfer of thermal energy and molecular collisions.
- Calculate the heat (q) absorbed or released by a system undergoing heating/ cooling based on the amount of the substance, the heat capacity, and the change in temperature.
- Explain changes in the heat (q) absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and the molar enthalpy of the phase transition.
- Calculate the heat (q) absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and the molar enthalpy of reaction.
- Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction.
- Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation.

● Represent a chemical or physical process as a sequence of steps. ● Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps.
Unit Duration:
4 Weeks

Unit 8: Equilibrium		
Standards	**Transfer Goal(s) /Big Ideas**	
9-12.PS1.B.2	BIG IDEA 3: TRANSFORMATIONS At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.	
	Enduring Understandings	**Essential Questions**
	● Some reactions can occur in both forward and reverse directions, sometimes ● proceeding in each direction simultaneously. ● A system at equilibrium depends on the relationships between concentrations,	● What observable processes are reversible? ● What are important reversible chemical processes? ● What happens when equilibrium is reached? ● Why is the equilibrium state dynamic?

	partial pressures of chemical species, and equilibrium constant K. ● Systems at equilibrium respond to external stresses to offset the effect of the stress. ● The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions.	● How can graphs of concentration, partial pressure, or rate of reaction versus time for simple chemical reactions be used? ● What happens if the rate of the forward reaction is greater than the reverse reaction? ● What happens if the rate of the reverse reaction is greater than that of the forward reaction? ● What does the reaction quotient Qc describe? ● For gas phase reactions, how is the reaction quotient written? ● What does the reaction quotient tend toward? ● What does the reaction quotient not include? ● How can equilibrium constants be determined? ● What happens if a reaction has a very large K value? ● What happens if a reaction has a very small K value? ● What happens when a reaction is reversed? ● What happens when the stoichiometric coefficients of a reaction are multiplied by a factor c? ● What happens when reactions are added together?

		● Why do all valid algebraic manipulations of K also apply to Q? ● How can the concentrations or partial pressures of species at equilibrium be predicted? ● How can particulate representations be used? ● How can Le Châtelier's principle be used to predict the response of a system to stresses? ● How can Le Châtelier's principle be used to predict the effect that a stress will have on experimentally measurable properties? ● What happens when a disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of equilibrium? ● Why do some stresses, such as changes in concentration, cause a change in Q only? ● Why do some stresses, such as change in temperature cause a change in K? ● How can the dissolution of a salt be described? ● How can the solubility of a substance be calculated? ● How can Ksp be used to predict the relative solubility of different substances? ● How can the solubility rules (see TRA-2.A.5) be quantitatively related to K_{sp}? ● When is the solubility of a salt reduced?

		● How can the impact of the “common-ion effect” on solubility be understood qualitatively using Le Châtelier’s principle or calculated from the Ksp for the dissolution process? ● Why is the solubility of a salt pH sensitive when one of the constituent ions is a weak acid or base? ● What factors does the free energy change (ΔG°) for dissolution reflect?

Learning Targets

Students will…

- Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations.
- Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.
- Represent the reaction quotient Qc or Qp , for a reversible reaction, and the corresponding equilibrium expressions Kc = Qc or K p = Qp .
- Calculate Kc or K p based on experimental observations of concentrations or pressures at equilibrium
- Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium.
- Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction.
- Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.
- Represent a system undergoing a reversible reaction with a particulate model.
- Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle.
- Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium.
- Calculate the solubility of a salt based on the value of K sp for the salt.
- Identify the solubility of a salt, and/or the value of K sp for the salt, based on the concentration of a common ion already present in solution.
- Identify the qualitative effect of changes in pH on the solubility of a salt.
- Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process.

Unit Duration:
4 Weeks

Unit 9: Acid-Base Chemistry		
Standards	**Transfer Goal(s) /Big Ideas**	
9-12.PS1.B.2	BIG IDEA 2: STRUCTURE AND PROPERTIES Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.	
	Enduring Understandings	**Essential Questions**
	● The chemistry of acids and bases involves reversible proton-transfer reactions, with equilibrium concentrations being related to the strength of the acids and bases involved. ● A buffered solution resists changes to its pH when small amounts of acid or base are added.	● How are the concentrations of hydronium ion and hydroxide ion, often reported as pH and pOH, respectively, calculated? ● What is the value of the equilibrium constant? ● What are the pH and pOH in pure water? ● What happens to the value of Kw if temperature is altered?

		● How does the concentration of a strong acid relate to the concentration of hydronium formed when the acid ionizes? ● How does the concentration of a strong base relate to the concentration of hydroxide ions formed when the base ionizes? ● How does the concentration of a weak acid relate to the concentration of hydronium ions formed when ionized? ● How are K_a and pK_a calculated? ● How does the concentration of a weak base relate to the concentration of hydroxide ions formed when ionized? ● How are K_a and pK_a calculated? ● How is the percent ionization of a weak acid (or base) calculated? ● What equation can be used to represent the reaction between a strong acid and a strong base? ● How can the pH of the reaction between a strong acid and a strong base be determined? ● What equation is used to represent the reaction between a weak acid and a strong base? ● How is the pH of a weak acid/strong base reaction calculated under the following conditions: a. If the weak acid is in excess?

		b. If the strong base is in excess? c. If they are equimolar? ● What equation is used to represent the reactions between a weak base and a strong acid? ● How is the pH of a strong acid/weak base reaction calculated under the following conditions: a. If the weak base is in excess?t b. If the strong acid is in excess? c. If they are equimolar? ● What equation is used to represent the reaction between a weak acid and a weak base? ● What is a titration? ● What is a titration curve utilized for? ● What is occurring at the equivalence point? ● Why is the equivalence point important? ● Why is it important to consider the half-equivalence point for titrations of weak acids/bases? ● For polyprotic acids, how can titration curves be used to determine the number of acidic protons? ● What are the strengths of the conjugate bases formed by strong acids? ● What are the strengths of the conjugate acids formed by strong bases?

		● How can the protonation state of an acid or base (i.e., the relative concentrations of HA and A−) be predicted? ● What are acid-base indicators? ● What are the components of a buffer solution? ● How do the components of a buffer solution stabilize pH when acid or base is added to the buffer solution? ● What is the pH of the buffer related to? ● How can the pH of a buffer be calculated? ● What effect does adding small amounts of acid or base to a buffered solution have on the ratio of [A−]/[HA] and solution pH? ● How does the change in pH on the addition of acid or base to a buffered solution compare to the change in pH in the absence of the buffer? ● What effect does increasing the concentration of buffer components (while keeping the ratio of these concentrations constant) have on the pH of the buffer and the capacity of the buffer to neutralize added acid or base? ● When a buffer has more conjugate acid than base, how does that affect the buffer capacity? ● When a buffer has more conjugate base than acid, how does that affect?

Learning Targets
Students will… ● Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water. ● Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. ● Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base ● Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. ● Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components. ● Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. ● Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base. ● Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution. ● Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer ● Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution.
Unit Duration:
3-4 Weeks

<table>
<tr><th colspan="3">Unit 10: Applied Thermodynamics</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS3.B.1
9-12.PS1.A.5</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.

BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.

BIG IDEA 4: ENERGY
Energy has two important roles in characterizing and controlling chemical systems. The first is accounting for the distribution of energy among the components of a system and the ways that heat exchanges, chemical reactions, and phase transitions redistribute this energy. The second is in considering the enthalpic and entropic driving forces for a chemical process. These are closely related to the dynamic equilibrium present in many chemical systems and the ways in which changes in experimental conditions alter the positions of these equilibria.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
</table>

	● Some chemical or physical processes cannot occur without intervention. ● The relationship between ΔG° and K can be used to determine favorability of a chemical or physical transformation. ● Electrical energy can be generated by chemical reactions.	● When does entropy increase? ● How does kinetic molecular theory (KMT) explain the relationship between entropy and temperature? ● How can the entropy change for a process be calculated? ● What symbol is the Gibbs free energy change for a chemical process in which all the reactants and products are present in a standard state (as pure substances, as solutions of 1.0 M concentration, or as gases at a pressure of 1.0 atm (or 1.0 bar)) given? ● What does the standard Gibbs free energy change for a chemical or physical process is a measure? ● How has the term “spontaneous” been used to describe processes for which $\Delta G^{o} < 0$? ● Why is the phrase “thermodynamically favored” preferred instead of “Spontaneous” when referring to processes with a $\Delta G^{o} < 0$? ● How can you determine the standard Gibbs free energy change for a physical or chemical process from the standard Gibbs free energy of formation of the reactants and products? ● Is it necessary to consider both enthalpy and entropy to determine if a process will

		be thermodynamically favored? The freezing of water and the dissolution of sodium nitrate are examples of such phenomena. ● Can you directly calculate the values of ΔG° from values of ΔH° and ΔS° for a process at a given temperature? ● Can the temperature conditions for a process be thermodynamically favored ($\Delta G^\circ < 0$) be predicted from the signs of ΔH° and ΔS° as shown in the table below: ● How can ΔG° be used to determine if a process is thermodynamically favored or thermodynamically favored ? ● Do processes that are thermodynamically favored occur to any measurable extent, or do they occur at extremely slow rates? ● Why would a process be thermodynamically favored, but does not proceed at a measurable rate?

ΔH°	ΔS°	Symbols	$\Delta G^\circ < 0$, favored a
< 0	> 0	$< >$	all T
> 0	< 0	$> <$	no T
> 0	> 0	$> >$	high T
< 0	< 0	$< <$	low T

		● What role does a high activation energy have with respect to kinetic control? ● Does the fact that a process does not proceed at a noticeable rate mean that the chemical system is at equilibrium? ● IIf a process is known to be thermodynamically favored, and yet does not occur at a measurable rate, is it reasonable to conclude that the process is under kinetic control? ● What phrase means that the products are favored at equilibrium (K > 1)? ● How is the equilibrium constant related to free energy? ● How can connections between K and ΔG° be made? ● When ΔG° is near zero, what would the value of the equilibrium constant be and how is that different from when ΔG° is much larger or much smaller than RT? ● What do processes with ΔG° < 0 favor (i.e., K > 1) and what do processes with ΔG° > 0 favor (i.e., K < 1)? ● What can be used to make a thermodynamically unfavorable process occur? Examples include: a. Electrical energy to drive an electrolytic cell or charge a battery. b. Light to drive the overall conversion of carbon dioxide to glucose in photosynthesis.

		● Can a desired product be formed by coupling a thermodynamically unfavorable reaction that produces that product to a favorable reaction (e.g., the conversion of ATP to ADP in biological systems)? ● In the coupled system, do individual reactions share one or more common intermediates? ● How can the sum of the individual reactions produce an overall reaction that achieves the desired outcome and has $\Delta G^\circ < 0$? ● What role does each component of an electrochemical cell (electrodes, solutions in the half-cells, salt bridge, voltage/current measuring device) play in the overall functioning of the cell? ● How would you describe the the operational characteristics of the cell (galvanic vs. electrolytic, direction of electron flow, reactions occurring in each half-cell, change in electrode mass, evolution of a gas at an electrode, ion flow through the salt bridge) on both the macroscopic and particulate levels? ● What are the terms referring to cells that involve a thermodynamically favored reaction and cells that involve a thermodynamically favored reaction? ● How are visual representations of galvanic and electrolytic cells used to identify where

		half-reactions occur and in what direction current flows? ● For all electrochemical cells, where does oxidation occur and where does reduction occur? ● What is the study of redox reactions that occur within electrochemical cells? ● With respect to thermodynamic favor and voltage, how can oxidation-reduction reactions be classified?How can the standard cell potential of electrochemical cells be calculated using the oxidation and reduction half-reactions and their respective standard reduction potentials? ● What is ΔGo (standard Gibbs free energy change) is proportional to for the redox reaction from which it is constructed.? ● What sign of Eo involves a thermodynamically favored reaction and what sign corresponds to a thermodynamically unfavored reaction? ● How does the cell potential vary depending on the concentrations of the active species in a real system under nonstandard conditions? ● What is a driving force toward equilibrium for electrolytic cells? ● How is the magnitude of the cell potential influenced by distance from equilibrium?.

		● Why do principles such as Le Châtelier's principle not apply to electrochemical systems? ● What does the standard cell potential Eo correspond to under standard conditions? ● As the system approaches equilibrium, how does the magnitude (i.e., absolute value) of the cell potential change as it reaches zero at equilibrium (when Q = K)? ● How do deviations from standard conditions that take the cell further from equilibrium than Q = 1 will affect the magnitude of the cell potential relative to Eo? ● How do deviations from standard conditions that take the cell closer to equilibrium than Q = 1 will affect the magnitude of the cell potential relative to Eo ? ● In concentration cells, how can the direction of spontaneous electron flow be determined by considering the direction needed to reach equilibrium? ● Considering that algorithmic calculations using the Nernst equation are insufficient to demonstrate an understanding of electrochemical cells under nonstandard conditions, how can students qualitatively understand the effects of concentration on cell potential and use conceptual reasoning,

		including the qualitative use of the Nernst equation: EQN: $E = E^{o} - (RT/nF) \ln Q$ to solve problems? ● How can Faraday's laws be used to determine the stoichiometry of the redox reaction occurring in an electrochemical cell with respect to the following: a. Number of electrons transferred b. Mass of material deposited on or removed from an electrode c. Current d. Time elapsed e. Charge of ionic species EQN: $I = q/t$?

Learning Targets

Students will…

- Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes.
- Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.
- Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG^{o} .
- Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.
- Explain whether a process is thermodynamically favored using the relationships between K, ΔG^{o} , and T.
- Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.
- Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell.
- Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell.
- Explain the relationship between deviations from standard cell conditions and changes in the cell potential.
- Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell.

Unit Duration:

2-3 Weeks

Strand 1: 9-12.PS1.A.1			
Topic: Periodic Table and Element Properties			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict an element's properties based on its position on the periodic table and the element's atomic structure. ● Can explain the effects of Coulomb's law, the shell model and the concept of shielding on an element's properties/behavior. ● Will be able to describe how changing the number of subatomic particles affects the properties and behaviors of an element. ● Will be able to draw conclusions and justify their response with evidence from spectroscopy data. ● Explain the properties of an absorbed or emitted photon in relationship to an electronic transition in an atom or molecule. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Represent the electron configuration of an element or ions of an element using the Aufbau principle. ● Can represent a substance's mass, moles, number of particles, as well as formula in a quantitative way. ● Will be able to identify an element based on evidence from spectroscopy data. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Strand 2: 9-12.PS1.A.2			
Topic: Chemical Reactions			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can justify why resulting products are formed in chemical reaction based on reactant oxidation numbers, reactivity, valence electrons and formal charge ● Can differentiate between physical and chemical changes and justify their claim with evidence ● Can explain how differences in electron behavior lead to differences in bonds formed ● Represent a given chemical reaction or physical process with a consistent particulate model. ● Identify the equivalence point in a titration based on the amounts of the titrant and analyte, assuming the titration reaction goes to completion. ● Identify species as BrønstedLowry acids, bases, and/or conjugate acid-base pairs, based on proton-transfer involving those species. ● Represent a balanced redox reaction equation using half-reactions.		

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	● Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or a base is added to a buffered solution. ● Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer ● Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and conjugate base components of the solution. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Identify evidence of chemical and physical changes in matter. ● Identify a reaction as acid-base, oxidation-reduction, or precipitation. ● Represent changes in matter with a balanced chemical or net ionic equation: ○ For physical changes. ○ For given information about the identity of the reactants and/or product. ○ For ions in a given chemical reaction. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 3: 9-12.PS1.A.3			
Topic: Bonding and Intermolecular Forces			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will describe how bonds are formed with respect to the electron activity of the bonding elements. ● Based on the relationship between Lewis diagrams, VSEPR theory, bond orders, and bond polarities: a. Explain structural properties of molecules. b. Explain electron properties of molecules. ● Can explain how physical features of a substance relate to the arraignment of their particles. ● Represent an ionic solid with a particulate model that is consistent with Coulomb's law and the properties of the constituent ions. ● Represent a metallic solid and/or alloy using a model to show essential characteristics of the structure and interactions present in the substance. ● Represent a molecule with a Lewis diagram that accounts for resonance between equivalent structures or that uses formal charge to select between nonequivalent structures. ● Explain the relationship between the chemical structures of molecules and the relative strength of their intermolecular forces when: ○ The molecules are of the same chemical species.		

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	○ The molecules are of two different chemical species. ● Explain the relationship between the motion of particles and the macroscopic properties of gases with: ○ The kinetic molecular theory (KMT) ○ A particulate model ○ A graphical representation ● Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volumes. ● Explain the relationship between the solubility of ionic and molecular compounds in aqueous and nonaqueous solvents, and the intermolecular interactions between particles. ● Explain the relationship between the strength of an acid or base and the structure of the molecule or ion. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Represent the relationship between potential energy and distance between atoms, based on factors that influence the interaction strength. ● Represent a molecule with a Lewis diagram. ● Represent the differences between solid, liquid, and gas phases using a particulate level model. ● Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law. ● Using particulate models for mixtures: ○ Represent interactions between components. ○ Represent concentrations of components. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand 4: 9-12.PS1.B.3			
Topic: Chemical Quantities			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can represent chemical quantities in a mathematical way. ● Can predict an unknown quantity by using a computational pathway with appropriate precision. ● Can describe how matter is conserved in any chemical reaction. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can balance chemical reactions in a symbolic way using chemical equations ● Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept. ● Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance. ● Explain the quantitative relationship between the elemental composition by mass and the composition of substances in a mixture. ● Calculate the number of solute particles, volume, or molarity of solutions.		

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	● Explain the amount of light absorbed by a solution of molecules or ions in relationship to the concentration, path length, and molar absorptivity. ● Calculate pH and pOH based on concentrations of all species in a solution of a strong acid or a strong base. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand 5: 9-12.PS1.A.4			
Topic: Intermolecular Forces and Experimental Design			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can predict the results of a change in laboratory procedure. ● Can evaluate a claim or a model with experimental evidence through proper scientific argumentation. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Can develop a laboratory procedure to safely carry out a valid experiment. ● Can develop graphical representations of scientific data for use in argumentation.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand 5: 9-12.PS1.A.5			
Topic: Thermodynamics			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** **9-12.PS1.A.5 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can predict the effects of changing temperature on particle behavior and energy changes. ● Can develop a model on the particle level how kinetic energy and its transfer relates to heat. ● Can describe changes in enthalpy with respect to bond breakage and formation ● Can apply Hess's law to predict the overall enthalpy change in a reaction ● Will illustrate how thermal equilibrium can be reached between two substances at different temperature ● Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG^{o} . ● Explain whether a process is thermodynamically favored using the relationships between K, ΔG^{o} , and T.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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	● Explain the relationship between deviations from standard cell conditions and changes in the cell potential. **The student exhibits no major errors or omissions.**		
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Will be able to describe the relationships between temperature, energy, and particle behaviors ● Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation. ● Represent a chemical or physical transformation with an energy diagram. ● Explain the relationship between the transfer of thermal energy and molecular collisions. ● Calculate the heat (q) absorbed or released by a system undergoing heating/ cooling, a phase transition, and a chemical reaction. ● Calculate the enthalpy change for a chemical or physical process based on the standard enthalpies of formation. ● Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes. ● Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process. ● Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate. ● Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the cell. ● Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell. ● Calculate the amount of charge flow based on changes in the amounts of reactants and products in an electrochemical cell. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand 5: 9-12.PS1.B.1			
Topic: Chemical Kinetics			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
			9-12.PS1.B.1 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● can predict how adjustments in concentration, temperature, surface area or introduction of a catalyst affects the rate of a chemical reaction ● can describe at a particle level how factors such as particle orientation, rate of collision, force of collision and presence of a catalyst affects the rate of a chemical reaction ● can explain the role of elementary reactions in determining the overall rate of reaction ● Identify the rate law for a reaction from a mechanism in which the first step is not rate limiting. ● Represent the activation energy and overall energy change in a multistep reaction with a reaction energy profile. **The student exhibits no major errors or omissions.**		

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	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Represent experimental data with a consistent rate law expression. ● Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time. ● Represent an elementary reaction as a rate law expression using stoichiometry ● Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile. ● Identify the components of a reaction mechanism. ● Identify the rate law for a reaction from a mechanism in which the first step is rate limiting. ● Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 5: 9-12.PS1.B.2			
Topic: Equilibrium Systems			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** **9-12.PS1.B.2 Refine the design of a chemical system by specifying a change in conditions that would alter the amount of products at equilibrium.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle. ● Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations. ● Explain the relationships between Q, K, and the direction in which a reversible reaction will proceed to reach equilibrium. ● Can calculate changes in concentrations or partial pressures in an equilibrium reaction using K, Q, Ksp, or Kw values. ● Can describe how the dissolution of a substance occurs on a particle level.		

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	● Represent a multistep process with an overall equilibrium expression, using the constituent K expressions for each individual reaction. ● Represent a system undergoing a reversible reaction with a particulate model. ● Identify the solubility of a salt, and/or the value of K sp for the salt, based on the concentration of a common ion already present in solution. ● Identify the qualitative effect of changes in pH on the solubility of a salt. ● Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases. ● Explain results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components. ● Explain the relationship between the predominant form of a weak acid or base in solution at a given pH and the pKa of the conjugate acid or the pKb of the conjugate base. **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions. ● Represent the reaction quotient Qc or Qp , for a reversible reaction, and the corresponding equilibrium expressions Kc = Qc or K p = Qp . ● Calculate Kc or Kp based on experimental observations of concentrations or pressures at equilibrium ● Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium.	

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	● Identify the concentrations or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant. ● Calculate the solubility of a salt based on the value of K sp for the salt. ● Calculate the values of pH and pOH, based on Kw and the concentration of all species present in a neutral solution of water. ● Explain the relationship among pH, pOH, and concentrations of all species in a solution of a monoprotic weak acid or weak base **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Physics ***Course Overview***	
Grade level(s): 11th - 12th	**Credits earned:** (Science) 1 Unit
Course Rationale	**Course Description**
Scientists use experiments to investigate the universe by collecting data to create mathematical models to explain and predict what they see. This course will help students develop the skills needed to be scientists. Students seeking careers in the STEM fields will need the skills taught in honors physics to be successful in these fields.	
Transfer Goals/Big Ideas	
● Asking Questions and Defining Problems ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information	
Priority Missouri Learning Standards/National Standards	
From National AP Physics Standards (College Board) **Science Practices** <u>2: Question and Method: Determine scientific questions and methods.</u> 2.A Identify a testable scientific question or problem.	

2.B Make a claim or predict the results of an experiment.
2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup).
2.D Make observations or collect data from representations of laboratory setups or results.
2.E Identify or describe potential sources of experimental error.
3: Representing Data and Phenomenon: Create visual representations or models of physical situations.
3.A Select and plot appropriate data.
3.C Sketch a graph that shows a functional relationship between two quantities.
4: Data and Analysis: Analyze quantitative data represented in graphs.
4.A Identify and describe patterns and trends in data or a graph.
4.C Linearize data and/or determine a best fit line or curve.
7: Argumentation: Develop an explanation or a scientific argument
7.A Make a scientific claim.
7.B Support a claim with evidence from experimental data.
7.F Explain how potential sources of experimental error may affect results and/or conclusions

Content Standards

CHA-1 There are relationships among the vector quantities of position, velocity, and acceleration for the motion of a particle along a straight line

CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration.

CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.

CHA-2 There are multiple simultaneous relationships among the quantities of position, velocity, and acceleration for the motion of a particle moving in more than one dimension with or without net forces

CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference.

CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations.
CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory.
CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.
INT-1 A net force will change the translational motion of an object.
INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks).
INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium.
INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines).
INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.).
INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional relationship in different physical situations (e.g., object sliding on surface or object not slipping on incline).
INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations.
INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on truck bed, an object at rest on incline, or an object pinned to a horizontal surface).
INT-3 There are force pairs with equal magnitude and opposite directions between any two interacting objects.
INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords).

INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys).

INT-4 When a force is exerted on an object, and the energy of the object changes, then work was done on the object.

INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero. (In honors physics, only constant forces will be addressed.)

INT-4.B Calculate a value for work done on an object from a force versus position graph.

INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces.

CON-1 Conservative forces internal to the system can change the potential energy of that system.

CON-1.D a. Derive the expression for the potential energy function of an ideal spring.

CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field.

CON-2 The energy of a system can transform from one form to another without changing the total amount of energy in the system.

CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant.

CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a "conservative" mechanical system.

CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force.

Unit 1: Experimental Methods
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● Practice 2A,B,C,D,E
● Practice 3 A,B,C
● Practice 4 A,C
● Practice 7 A,B,F</td><td colspan="2">● Scientists use experiments to investigate the universe.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Scientists use experiments to investigate the universe. They use the data collected to create mathematical models to explain and predict what they see. Scientists must be able to explain their work and defend it if it is going to be accepted as “true.”</td><td>● How do scientists design experiments?
● How do scientists determine if something is “true”?
● How and why do scientists model what happens in the real world?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Design and conduct a valid experiment to answer a question.
● Describe possible sources of experimental error and suggest ways to adjust the procedure to minimize this error.
● Analyze data using graphs and appropriate software to determine the relationship between variables. Students should be able to describe several types of relationships (linear, proportional, quadratic and inverse) verbally, graphically and mathematically.
● Explain the connection between their data and graphs to the overall model (mathematical, graphical, verbal) of a given system. They can describe this connection in class discussions and in written form and use these models to predict future behavior.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">Year long. This unit will focus on the basics of designing, conducting and analyzing experiments. Students will be implementing these standards in every unit for the duration of the course.</td></tr>
</table>

<table>
<tr><th colspan="3">Unit 2: Kinematics (1-D and 2-D motion)
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard)

● CHA-1
● CHA-2</td><td colspan="2">● Graphs, equations and diagrams can be used to model and predict motion.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● Motion can only be defined relative to an arbitrary frame of reference.
● A vector is a quantity that incorporates direction.
● Graphs and equations can be used to model and predict motion.
● The vertical and horizontal components of the motion of a projectile are independent of each other. Because of this, one dimensional models can be used to analyze two dimensional projectile motion.
● Bodies in free fall have the same acceleration regardless of mass.</td><td>● How can we model and predict the motion of an object?
● What is acceleration?
● Do heavier things fall faster?
● How can graphs be used to model and analyze motion?
● How do we model 2-dimensional motion?</td></tr>
</table>

Learning Targets
Students will… ● *Break a 2D vector into components, or given components can find the magnitude and direction.* ● *Add two parallel or perpendicular vectors together.* ● *Students can model 1-D motion with various graphs, equations and diagrams.* ● *Given a motion graph (x vs t, v vs t, a vs t) students can sketch the other two graphs and describe the motion being modeled .* ● *Correctly use the kinematic equations in problem solving, including free fall situations.* ● *Solve problems involving projectiles launched at any angle from the ground or launched horizontally from any height. (Can predict range, launch velocity, etc.)*
Unit Duration:
These standards will be split into multiple units, taught over several months. The first part of this unit will cover 1-D motion for objects moving with a constant velocity. The 2nd part will cover accelerated motion including objects in free fall. This unit concludes with 2-D motion.

<table>
<tr><th colspan="3">Unit 3: Newton's Laws
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">INT-1
INT-3</td><td colspan="2">A force is needed to change the motion of an object (accelerate), not to cause motion. This acceleration is related to the net force and mass of the system.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>A force is an interaction between two objects that affects both objects equally. (Newton's 3rd)
A force is needed to change the motion of an object, not to cause motion. (Newton's 1st)
Acceleration occurs only when a net force acts on a system. The acceleration is proportional to the force and inversely proportional to the mass of the system. (Newton's 2nd)</td><td>What are forces and what do they do?
What causes acceleration?
What factors affect this acceleration?
What is equilibrium and how can we determine if something is in equilibrium?</td></tr>
</table>

Learning Targets
Students will… ● *Understand that a force is an interaction between two objects that can result in acceleration.* ● *Understand that the net force affects the motion of an object and can use the net force to predict if the object accelerates.* ● *Understand that tension and normal forces occur as the result of distortions (stretches/compressions) of an object.* ● *Understand the concept of coefficient of friction and can differentiate between static and kinetic friction.* ● *Identify when various types of forces (gravity, friction, normal, tension) occur and the direction they act.* ● *Understand the difference between mass and weight and can calculate one if given the other.* ● *State Newton's 3rd Law and can use it to explain situations such as why a rocket rises or how we walk.* ● *Use the expression Ff = mu x Fn to calculate the force of friction, understanding when to use the inequality/equality.* ● *Understand Hooke's Law and use this law to calculate tension, spring constant or distortion.* ● *Use Newton's 1st and 2nd Law to predict the motion of objects or can use the motion to find the value of the forces needed to produce it.* ● *Draw a force diagram to represent the individual forces that act on a system.* ● *Write summation statements to represent the net force acting on an object in the x and y directions.* ● *Give the Newton's 3rd law pair force for any given force.* ● *Apply Newton's 3rd Law to problem solving involving multiple objects.*
Unit Duration:
The strand will be split into 2 units, covered over a couple months.

<table>
<tr><th colspan="3"> 
Unit 4: Work and Energy
Desired Results</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● INT-4
● CON-1
● CON-2</td><td colspan="2">● Energy cannot be created or destroyed, only transferred.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Energy can be stored in various ways and can be transferred from system to system, but the total amount always remains the same.
● Work is the transfer of energy from system to system via a force.</td><td>● How can energy be stored and what does it do?
● How can energy be moved from place to place?
● What characteristics of a system show energy is stored there?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Understand that work is the transfer of energy into or out of a system by means of a force and can identify situations in which work is done.
● State the Law of Conservation of Energy.
● Distinguish open and closed systems and when work is/is not done.
● Identify energy storage and changes within a system and represent this change with a diagram (pie chart or bar graph.)
● Use formulae to correctly calculate the amount of energy stored.
● Calculate the work done by using the relation W = F x d x cos(theta) or by using the area under a force vs. position graph.
● Use the law of conservation of energy, and the concept of work to predict the behavior/characteristics of objects in an open or closed system.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">2-4 weeks.</td></tr>
</table>

Strand: Experimental Methods, Practices 2, 3, 4, 7		
Grade: 11th-12th		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** 2.A Identify a testable scientific question or problem. 2.B Make a claim or predict the results of an experiment. 2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup). 2.D Make observations or collect data from representations of laboratory setups or results. 2.E Identify or describe potential sources of experimental error. ● Given a system to analyze, students can design and carry out a valid experiment to model the situation. This includes choosing an appropriate range of values for the independent variable and taking a sufficient number of trials. ● They can clearly describe the purpose and procedure of their experiment in a written report. 3.A Select and plot appropriate data. 3.C Sketch a graph that shows a functional relationship between two quantities. 4.A Identify and describe patterns and trends in data or a graph. 4.C Linearize data and/or determine a best fit line or curve. ● Will analyze their own lab results to determine the specific relationship between the variables and can model this relationship with a graph, with an equation and describe it precisely in words.	● Students will be designing and carrying out experiments. ● Students will look at sample data/graphs and describe possible reasons for error in the results. ● Students will report sources of error and analyze their own results. ● Students will analyze their own experimental results and report their analysis. ● Students will conduct experiments and analyze the results. They will present their findings to the class and defend their conclusions. ● Students will ask questions in a Socratic format to understand/evaluate the models of other students.

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	● In linear relationships, students can describe what the slope and y-intercept of the graph tell about the system. 7.A Make a scientific claim. 7.B Support a claim with evidence from experimental data. 7.F Explain how potential sources of experimental error may affect results and/or conclusions ● Will analyze the results of their experiments to build a model that describes not only the specific situation in the lab, but a more general model of similar systems. This model should be given in graphical, mathematical and verbal formats. ● Clearly states under what circumstances their model is valid/useful. ● Clearly defends/explains the model they have constructed in class discussion and in written reports. They can also evaluate other student presentations. **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Identifies features of a well-designed experiment, such as dependent, independent variables. ● Knows that measurements must be repeated to minimize error. Therefore, when doing experiments, students will take multiple trials over a large range of values. ● Identifies possible sources of error, and can alter their procedure to minimize the effect of that error in their experiments. They can explain what effect the error could have on the results. ● Recognizes linear, proportional, quadratic and inverse relationships on graphs. ● Uses appropriate software to create and analyze graphs which are properly scaled and labeled. ● Will state and explain the general model, (i.e the conclusions the class came to as a result of the experiment.)	● Students will read descriptions of experimental procedures and determine if the experiment is valid and identify the independent/dependent variables. ● Students will practice making and analyzing graphs using Vernier Graphical Analysis software.

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: Kinematics (1-D and 2-D motion) CHA-1, CHA-2			
Grade: 11th & 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration. CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. ● Explain what a reference frame is and why it is necessary to describe quantities such as position or velocity. Will define an appropriate reference frame when problem solving. Students can modify the frame from the standard to make solutions easier/more efficient. ● Will model more complex motion (object turns around, or undergoes different types of motion at different times) in graphs ● Can use the basic kinematics equations to solve problems ● Will sketch and use appropriate graphs when problem solving. ● Uses experimental data to determine the acceleration due to gravity. ● Will describe, qualitatively, the effect of air resistance/drag on a moving object.		● Students apply vector skills in problem solving. ● In class discussion, students will share how they defined a reference frame to solve a problem. Students will compare different choices to see which made the problem simpler. ● Solve problems using both graphs and equations, and then in class discussions evaluate which methods are easiest/most efficient. ● Students will use a video of a projectile to analyze the motion. ● Projectile target shoot. Students must hit the bulls-eye! ● Students will conduct experiments, observing different types of motion and use the results to derive the basic kinematic equations. ● Given two cars a set distance apart, students predict where the cars will collide. We will then test their predictions.

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	CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference. CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations. CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory. CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. ● Will apply basic vector skills (listed below) when problem solving. Students know when it is appropriate to use the techniques, without reminders. ● Can add two parallel or perpendicular vectors together. ● Will solve problems involving projectiles launched horizontally from any height. ● Will correctly use the equations in problem solving ● After observing motion or reading a description of simple motion (moving in only one direction or only one type of motion), students can o build an position vs time graph o build a velocity vs time graph o draw a diagram (for example, a motion map) o write an equation to model the motion. ● Given a motion graph (x vs t, v vs t, a vs t) students can	

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	o Sketch the other two graphs o Describe the motion being modeled **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Knows the difference between vector and scalar quantities and can give examples of each. Students know how the directions of both one- and two-dimensional vectors are represented mathematically. ● Knows the definitions of basic vector terms, such as magnitude, resultant and component. ● Know what the variables in the following basic equations stand for. $(\vec{x} = \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2 , \overrightarrow{v_x} = \vec{v}_{0x} + \overrightarrow{a_x} t ,\ v_x^2 = v_{0x}^2 + 2\vec{a}_x(\vec{x} - \vec{x}_0))$ ● Uses a reference frame to describe the direction of vectors. ● Will differentiate between average and instantaneous quantities. ● Will describe what features of the graph (slope, y-intercept, area under the curve) tell us about the motion, if anything. ● Will break a 2D vector into components, or given components can find the magnitude and direction. ● Understands that the horizontal and vertical components of projectile motion are independent. They can use this understanding to qualitatively compare the motion of different projectiles. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	● Students will practice the mathematical skills needed to work with vectors. ● Students will practice describing the position of an object relative to various reference frames. ● Students mark the position (at different times) of a toy car moving down the hallway. Then analyze the data to build a model of the motion. ● Students do a similar analysis of an accelerating object. ● Students are given a position vs time graph and then determine how they must move in front of a motion detector to produce that graph. They then sketch velocity and acceleration graphs that also model the situation. ● Students will practice solving problems involving projectiles. ● Students will practice using the equations in problem solving.
	1.5 Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**	
	0.5 With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**	

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Strand: Newton's Laws INT-1, INT-3		
Grade: 11th & 12th		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks). INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium. INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines).	● Students will collect data on the stretch/compression of spring to derive Hooke's Law. ● Students will practice using the equations that model the magnitude of each force when problem solving. ● Students will collect data about the net force, mass and acceleration of a system in order to derive Newton's 2nd Law. ● Students will practice problem solving involving Newton's Laws.

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	INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.). INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional relationship in different physical situations (e.g., object sliding on surface or object not slipping on incline). INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations. INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on a truck bed, an object at rest on an incline, or an object pinned to a horizontal surface). ● Will derive Newton's 1st and 2nd law based on observations and data collected in the lab. ● Uses Newton's 1st and 2nd Law to predict the motion of objects in more complex problems or can use the motion to find the value of the forces needed to produce it in more complex situations (inclined planes, forces in both x & y directions) ● Uses the"fun" equation to calculate the force of friction, understanding when to use the inequality/equality. ● Understands Hooke's Law and can use this law to calculate tension, spring constant or distortion. INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords).	

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	INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys). ● Students will apply Newton's 3rd Law to problem solving involving multiple objects. ● Will state Newton's 3rd Law and can use it to explain situations such as why a rocket rises or how we walk. ● Will give the Newton's 3rd law pair force for any given force. **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Will identify when various types of forces (gravity, friction, normal, tension) occur and the direction they act. ● Understands that tension and normal forces occur as the result of distortions (stretches/compressions) of an object. ● Understands the concept of coefficient of friction and can differentiate between static and kinetic friction ● Understands the difference between mass and weight and can calculate one if given the other. ● Understands that a force is an interaction between two objects that can result in acceleration. Students understand that the net force affects the motion of an object and can use the net force to predict if the object accelerates. ● Will draw a force diagram to represent the individual forces that act on a system. Students can write summation statements to represent the net force acting on an object in the x and y directions. ● Use Newton's 1st and 2nd Law to predict the motion of an object in simple situations (motion in only x or y direction, only horizontal or vertical forces.) or can use the motion to find the value of unknown forces in simple situations.	● Students will conduct a lab, measuring both mass and weight to derive the relationship between the two for objects on Earth. ● Students will collect data on the normal force and friction acting on a block to investigate coefficients of friction for both static and kinetic cases. ● Students will observe objects moving with and without friction in order to derive/understand Newton's 1st Law. ● Students will practice drawing force diagrams for a variety of situations. Students will practice writing summation statements of forces based on a force diagram. ● Students will practice using those summation statements in problem solving. ● Students will investigate Newton's 3rd by comparing the forces objects exert on each other in a variety of situations.

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: Work and Energy INT-4, CON-1, CON-2			
Topic: Work and Energy			
Grade: 11th & 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero. INT-4.B Calculate a value for work done on an object from a force versus position graph. INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces. ● Will calculate the work done by a constant force using the relation $W = F\,\Delta x \cos\theta$.		● Students will collect data using springs to relate force, stretch and elastic energy. ● Students will use area under force vs. position graphs to derive the formulae. ● Students practice calculations of work with constant and non-constant forces (using graphs). ● Students will practice solving problems involving the conservation of energy. ● Students will use conservation of energy in the lab to predict the distance a bungee jumper will fall when dropped from a specified height.

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	● Will calculate the work done by a varying force using the area under a force vs. position graph. CON-1.D a. Derive the expression for the potential energy function of an ideal spring. CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field. CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant. CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a "conservative" mechanical system. CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force. ● Uses lab data to derive the formula for various energy storage mechanisms. ● Uses the formulae ($E_k = \frac{1}{2}mv^2$, $E_g = mgh$, $E_{el} = \frac{1}{2}k(\Delta x)^2$, $E_{Diss} = F_f \Delta x$) to correctly calculate the amount of energy stored. ● Use the law of conservation of energy, and the concept of work to predict the behavior/characteristics of objects in an open or closed system. (For example, to find the velocity or height of an object at a specific point, to find how much a spring will be compressed or to find how much heat is generated.) **The student exhibits no major errors or omissions.**	

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	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Understands that motion is the indicator of kinetic energy in a system and that the amount of Ek is related to the mass and velocity of the system. ● Understands that elevation is the indicator of gravitational energy in a system and that the amount of Eg is related to the mass, height and gravitational field. ● Understands that distortion is the indicator of stored elastic energy and that the amount of Eel is related to stretch/compression and spring constant. ● Understand that heat and sound are indicators of dissipated energy and that energy is dissipated most often by friction/drag and collision. ● So, students can use the indicators listed above to identify energy storage and changes within a system. ● Will state the Law of Conservation of Energy. ● Distinguishes between open and closed systems and when work is/is not done. ● Uses diagrams (pie charts or bar graphs) to show how the storage of energy changes in a system and to show that energy is conserved. ● Understands that work is the transfer of energy into or out of a system by means of a force and can identify situations in which work is done. ● Will explain why work is only done if the system is displaced in a direction that is parallel to a component of the force. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Students will practice identifying where the energy is stored in various situations. ● Students will analyze examples of forces and motion to determine if work is done. ● Students will describe the energy flow of the same situation with different systems to show that work is dependent on the choice of system. ● Students will practice modeling the energy flow with pie charts and bar graphs.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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AP Physics *Course Overview*	
Grade level(s):12	**Credits earned:** 1
Course Rationale	**Course Description**
From College Board: To foster a deeper level of learning, the AP Physics C: Mechanics course defines concepts, skills, and understandings required by representative colleges and universities for granting college credit and placement. Students will practice reasoning skills used by physicists by discussing and debating, with peers, the physical phenomena investigated in class, as well as by designing and conducting inquiry-based laboratory investigations to solve problems through first-hand observations, data collection, analysis, and interpretation.	*This course will prepare students for the AP Physics C exam. Students who pass the exam can earn college credit hours. Students will continue their studies of mechanics, including rotation, as well as adding a calculus component.*
Transfer Goals/Big Ideas	
● Asking Questions and Defining Problems ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information	
Priority Missouri Learning Standards/National Standards	

From College Board: AP Physics C: Mechanics

- Practices:

1: Visual Representations: Analyze and/or use [non-narrative/non-mathematical] representations of physical situations, excluding graphs

1.A Describe the physical meaning (includes identifying features) of a representation.

1.B Describe the relationship between different types of representations of the same physical situation.

1.C Demonstrate consistency between different types of representations of the same physical situation.

1.D Select relevant features of a representation to answer a question or solve a problem.

1.E Describe the effects of modifying conditions or features of a representation of a physical situation.

2: Question and Method: Determine scientific questions and methods.

2.A Identify a testable scientific question or problem.

2.B Make a claim or predict the results of an experiment.

2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup).

2.D Make observations or collect data from representations of laboratory setups or results.

2.E Identify or describe potential sources of experimental error.

2.F Explain modifications to an experimental procedure that will alter results

3: Representing Data and Phenomenon: Create visual representations or models of physical situations.

3.A Select and plot appropriate data.

3.B Represent features of a model or the behavior of a physical system using appropriate graphing techniques, appropriate scale, and units.

3.C Sketch a graph that shows a functional relationship between two quantities.

3.D Create appropriate diagrams to represent physical situations

4: Data and Analysis: Analyze quantitative data represented in graphs.

4.A Identify and describe patterns and trends in data or a graph.

4.B Demonstrate consistency between different graphical representations of the same physical situation.

4.C Linearize data and/or determine a best fit line or curve.

4.D Select relevant features of a graph to describe a physical situation or solve problems.

4.E Explain how the data or graph illustrates a physics principle, process, concept, or theory.

5: Theoretical Relationships: Determine the effects on a quantity when another quantity or the physical situation changes.

5.A Select an appropriate law, definition, mathematical relationship, or model to describe a physical situation.

5.B Determine the relationship between variables within an equation when an existing variable changes.

5.C Determine the relationship between variables within an equation when a new variable is introduced.

5.D Determine or estimate the change in a quantity using a mathematical relationship.
5.E Derive a symbolic expression from known quantities by selecting and following a logical algebraic pathway.
6: Mathematical Routines: Solve problems of physical situations using mathematical relationships.
6.A Extract quantities from narratives or mathematical relationships to solve problems.
6.B Apply an appropriate law, definition, or mathematical relationship to solve a problem.
6.C Calculate an unknown quantity with units from known quantities by selecting and following a logical computational pathway.
6.D Assess the reasonableness of results or solutions
7: Argumentation: Develop an explanation or a scientific argument
7.A Make a scientific claim.
7.B Support a claim with evidence from experimental data.
7.C Support a claim with evidence from physical representations.
7.D Provide reasoning to justify a claim using physical principles or laws.
7.E Explain the connection between experimental results and larger physical principles, laws, or theories.
7.F Explain how potential sources of experimental error may affect results and/or conclusions

- Content Standards

CHA-1 There are relationships among the vector quantities of position, velocity, and acceleration for the motion of a particle along a straight line
CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration.
CHA-1.B Determine functions of position, velocity, and acceleration that are consistent with each other, for the motion of an object with a nonuniform acceleration.
CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.
CHA-2 There are multiple simultaneous relationships among the quantities of position, velocity, and acceleration for the motion of a particle moving in more than one dimension with or without net forces
CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or

frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference.
CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations.
CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory.
CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.
INT-1 A net force will change the translational motion of an object.
INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks).
INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium.
INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines).
INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.).
INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional relationship in different physical situations (e.g., object sliding on surface or object not slipping on incline).
INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations.
INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on truck bed, an object at rest on incline, or an object pinned to a horizontal surface).

INT-1.H a. Derive an expression for the motion of an object freely falling with a resistive drag force (or moving horizontally subject to a resistive horizontal force). b. Describe the acceleration, velocity, or position in relation to time for an object subject to a resistive force (with different initial conditions, i.e., falling from rest or projected vertically).
INT-1.I Calculate the terminal velocity of an object moving vertically under the influence of a resistive force of a given relationship.
INT-1.J a. Derive a differential equation for an object in motion subject to a specified resistive force. b. Derive an expression for a time-dependent velocity function for an object moving under the influence of a given resistive force (with given initial conditions). c. Derive expressions for the acceleration or position of an object moving under the influence of a given resistive force.
INT-2 The motion of some objects is constrained so that forces acting on the object cause it to move in a circular path.
INT-2.A a. Calculate the velocity of an object moving in a horizontal circle with a constant speed, when subject to a known centripetal force. b. Calculate relationships among the radius of a circle, the speed of an object (or period of revolution), and the magnitude of centripetal acceleration for an object moving in uniform circular motion.
INT-2.B a. Explain how a net force in the centripetal direction can be a single force, more than one force, or even components of forces that are acting on an object moving in circular motion. b. Describe forces that are exerted on objects undergoing horizontal circular motion, vertical circular motion, or horizontal circular motion on a banked curve. c. Describe forces that are acting on different objects traveling in different circular paths.
INT-2.C a.Describe the direction of the velocity and acceleration vector for an object moving in two dimensions, circular motion, or uniform circular motion. b. Calculate the resultant acceleration for an object that changes its speed as it moves in a circular path.
INT-2.D Derive expressions relating centripetal force to the minimum speed or maximum speed of an object moving in a vertical circular path.
INT-2.E Derive expressions relating the centripetal force to the maximum speed of an object or minimum speed of an object moving in a circular path on a banked surface with friction.
INT-3 There are force pairs with equal magnitude and opposite directions between any two interacting objects.
INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords).
INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys).
INT-4 When a force is exerted on an object, and the energy of the object changes, then work was done on the object.
INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero.

INT-4.B Calculate a value for work done on an object from a force versus position graph.
INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces.
CON-1 Conservative forces internal to the system can change the potential energy of that system.
CON-1.A a. Compare conservative and dissipative forces. b. Describe the role of a conservative force or a dissipative force in a dynamic system.
CON-1.B a. Explain how the general relationship between potential energy functions and conservative forces is used to determine relationships between the two physical quantities. b. Derive an expression that represents the relationship between a conservative force acting in a system on an object to the potential energy of the system using the methods of calculus.
CON-1.C Describe the force within a system and the potential energy of a system
CON-1.D a. Derive the expression for the potential energy function of an ideal spring. b. Derive an expression for the potential energy function of a nonideal spring that has a nonlinear relationship with position.
CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field.
CON-1.F Derive an expression for the gravitational potential energy of a system consisting of a satellite or large mass (e.g., an asteroid) and the Earth at a great distance from the Earth.
CON-2 The energy of a system can transform from one form to another without changing the total amount of energy in the system.
CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant.
CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a "conservative" mechanical system.
CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force.
CON-2.D Derive expressions such as positions, heights, angles, and speeds for an object in vertical circular motion or pendulum motion in an arc.
CON-3 The energy of an object or a system can be changed at different rates
CON-3.A a. Derive an expression for the rate at which a force does work on an object. b. Calculate the amount of power required for an object to maintain a constant acceleration. c. Calculate the amount of power required for an object to be raised vertically at a constant rate.
CHA-3 The linear motion of a system can be described by the displacement, velocity, and acceleration of its center of mass.

CHA-3.A a. Calculate the center of mass of a system of point masses or a system of regular symmetrical objects. b. Calculate the center of mass of a thin rod of nonuniform density using integration
CHA-3.B Describe the motion of the center of the mass of a system for various situations.
CHA-3.C Explain the difference between the terms “center of gravity” and “center of mass,” and identify physical situations when these terms have identical positions and when they have different positions.
INT-5 An impulse exerted on an object will change the linear momentum of the object.
INT-5.A a. Calculate the total momentum of an object or a system of objects. b. Calculate relationships between mass, velocity, and linear momentum of a moving object.
INT-5.B Calculate the quantities of force, time of collision, mass, and change in velocity from an expression relating impulse to change in linear momentum for a collision of two objects.
INT-5.B Calculate the quantities of force, time of collision, mass, and change in velocity from an expression relating impulse to change in linear momentum for a collision of two objects.
INT-5.D Calculate the momentum change in a collision using a force versus time graph for a collision.
INT-5.E Calculate the change in momentum of an object given a nonlinear function, F(t), for a net force acting on the object.
CON-4 In the absence of an external force, the total momentum within a system can transfer from one object to another without changing the total momentum in the system.
CON-4.A a. Calculate the velocity of one part of a system after an explosion or a collision of the system. b. Calculate energy changes in a system that undergoes a collision or an explosion.
CON-4.B Calculate the changes of momentum and kinetic energy as a result of a collision between two objects.
CON-4.C Describe the quantities that are conserved in a collision.
CON-4.D Calculate the speed of the center of mass of a system.
CON-4.E a. Calculate the changes in speeds, changes in velocities, changes in kinetic energy, or changes in momenta of objects in all types of collisions (elastic or inelastic) in one dimension, given the initial conditions of the objects. b. Derive expressions for the conservation of momentum for a particular collision in one dimension.
CON-4.F a. Calculate the changes in speeds, changes in velocities, changes in kinetic energy, or changes in momenta of objects involved in a two-dimensional collision (including an elastic collision), given the initial conditions of the objects. b. Derive expressions for the conservation of momentum for a particular two-dimensional collision of two objects.
INT-6 When a physical system involves an extended rigid body, there are two conditions of equilibrium—a translational condition and a rotational condition.

INT-6.A a. Calculate the magnitude and direction of the torque associated with a given force acting on a rigid body system. b. Calculate the torque acting on a rigid body due to a gravitational force.
INT-6.B a. Describe the two conditions of equilibrium for an extended rigid body. b. Calculate unknown magnitudes and directions of forces acting on an extended rigid body that is in a state of translational and rotational equilibrium.
INT-6.C a. Explain the differences in the moments of inertia between different objects such as rings, discs, spheres, or other regular shapes by applying the general definition of moment of inertia (rotational inertia) of a rigid body. b. Calculate by what factor an object's rotational inertia will change when a dimension of the object is changed by some factor c. Calculate the moment of inertia of point masses that are located in a plane about an axis perpendicular to the plane.
INT-6.D a. Derive the moment of inertia, using calculus, of a thin rod of uniform density about an arbitrary axis perpendicular to the rod. b. Derive the moment of inertia, using calculus, of a thin rod of nonuniform density about an arbitrary axis perpendicular to the rod. c. Derive the moments of inertia for a thin cylindrical shell or disc about its axis or an object that can be considered to be made up of coaxial shells (e.g. annular ring).
INT-6.E Derive the moments of inertia of an extended rigid body for different rotational axes (parallel to an axis that goes through the object's center of mass) if the moment of inertia is known about an axis through the object's center of mass
CHA-4 There are relationships among the physical properties of angular velocity, angular position, and angular acceleration.
CHA-4.A a. Explain how the angular kinematic relationships for uniform angular acceleration are directly analogous to the relationships for uniformly and linearly accelerated motion. b. Calculate unknown quantities such as angular positions, displacement, angular speeds, or angular acceleration of a rigid body in uniformly accelerated motion, given initial conditions. c. Calculate unknown quantities such as angular positions, displacement, angular velocity, or rotational kinetic energy of a rigid body rotating with a specified non uniform angular acceleration.
CHA-4.B a. Explain the use of the relationships that connect linear translational motion to rotational motion in appropriate physical situations. b. Calculate the translational kinematic quantities from an object's rotational kinematic quantities for objects that are rolling without slipping. c. Calculate the (tangential) linear acceleration of a point on a rotating object given the object's angular acceleration.
INT-7 A net torque acting on a rigid extended body will produce rotational motion about a fixed axis.
INT-7.A a. Describe the complete analogy between fixed axis rotation and linear translation for an object subject to a net torque. B. Calculate unknown quantities such as net torque, angular acceleration, or moment of inertia for a rigid body undergoing rotational acceleration. c. Calculate the angular acceleration of an extended rigid body, of known moment of inertia, about a fixed axis or about its center of mass when it is experiencing a specified net torque due to one of several applied forces.
INT-7.B a. Describe the net torque experienced by a rigid extended body in situations such as, but not limited to, rolling down inclines, pulled along horizontal surfaces by external forces, a pulley system (with rotational inertia), simple pendulums, physical pendulums, and rotating bars. b. Derive an expression for all torques acting on a rigid body in various physical situations using Newton's second law of rotation.

INT-7.C Derive expressions for physical systems such as Atwood machines, pulleys with rotational inertia, or strings connecting discs or strings connecting multiple pulleys that relate linear or translational motion characteristics to the angular motion characteristics of rigid bodies in the system that are (a) rolling (or rotating on a fixed axis) without slipping. (b) rotating and sliding simultaneously.
INT-7.D a.Calculate the rotational kinetic energy of a rotating rigid body. B. Calculate the total kinetic energy of a rolling body or a body that has both translational and rotational motions. c. Calculate the amount of work done on a rotating rigid body by a specified force applied to the rigid body over a specified angular displacement.
INT-7.E Derive expressions using energy conservation principles for physical systems such as rolling bodies on inclines, Atwood machines, pendulums, physical pendulums, and systems with massive pulleys that relate linear or angular motion characteristics to initial conditions (such as height or position) or properties of rolling body (such as moment of inertia or mass).
CON-5 In the absence of an external torque, the total angular momentum of a system can transfer from one object to another within the system without changing the total angular momentum of the system.
CON-5.A a. Calculate the angular impulse acting on a rotating rigid body given specified angular properties or forces acting over time intervals. b. Calculate the angular momentum vector of a rotating rigid body in cases in which the vector is parallel to the angular velocity vector.
CON-5.B Calculate the angular momentum vector of a linearly translating particle about a defined stationary point of reference
CON-5.C a. Describe the conditions under which a rotating system's angular momentum is conserved. b. Explain how a one- or two-particle system (rotating object or satellite orbits) may have a change in angular velocity when other properties of the system change (such as radius or inertia)
CON-5.D a. Calculate changes in angular velocity of a rotating rigid body when the moment of inertia of the body changes during the motion (such as a satellite in orbit). b. Calculate the increase or decrease in angular momentum of a rigid body when a point mass particle has a collision with the rigid body. c. Calculate the changes of angular momentum of each disc in a rotating system of two rotating discs that collide with each other inelastically about a common rotational axis.
INT-8 There are certain types of forces that cause objects to repeat their motions with a regular pattern.
INT-8.A a. Describe the general behavior of a spring-mass system in SHM in qualitative terms. b. Describe the relationship between the phase angle and amplitude in an SHM system.
INT-8.B a. Describe the displacement in relation to time for a mass-spring system in SHM. b. Identify the period, frequency, and amplitude of the SHM in a mass-spring system from the features of a plot.
INT-8.C Describe each of the three kinematic characteristics of a spring-mass system in SHM in relation to time (displacement, velocity, and acceleration). For a spring-mass system in SHM— a. describe the general features of the motion and b. identify the places on a graph where these values are zero or have maximum positive values or maximum negative values.
INT-8.D Derive a differential equation to describe Newton's second law for a spring-mass system in SHM or for the simple pendulum.

INT-8.E Calculate the position, velocity, or acceleration of a spring-mass system in SHM at any point in time or at any known position from the initial conditions and known spring constant and mass
INT-8.F Derive the expression for the period of oscillation for various physical systems oscillating in SHM.
INT-8.G Calculate the mechanical energy of an oscillating system. Show that this energy is conserved in an ideal SHM spring-mass system.
INT-8.H Describe the effects of changing the amplitude of a spring-mass system.
INT-8.I Describe the kinetic energy as a function of time (or position), potential energy as a function of time (or position), and total mechanical energy as a function of time (or position) for a spring-mass system in SHM, identifying important features of the oscillating system and where these features occur.
INT-8.J Explain how the model of SHM can be used to determine characteristics of motion for other physical systems that can exhibit this behavior.
INT-8.K Describe a linear relationship between the period of a system oscillating in SHM and physical constants of the system.
FLD-1 Objects of large mass will cause gravitational fields that create an interaction at a distance with other objects with mass.
FLD-1.A Calculate the magnitude of the gravitational force between two large spherically symmetrical masses
FLD-1.B Calculate the value for g or gravitational acceleration on the surface of the Earth (or some other large planetary object) and at other points outside of the Earth.
FLD-1.C Describe the motion in a qualitative way of an object under the influence of a variable gravitational force, such as in the case where an object falls toward the Earth's surface when dropped from distances much larger than the Earth's radius.
CON-6 Angular momentum and total mechanical energy will not change for a satellite in an orbit.
CON-6.A Calculate quantitative properties (such as period, speed, radius of orbit) of a satellite in circular orbit around a planetary object.
CON-6.B Derive Kepler's third law for the case of circular orbits.
CON-6.C Describe a linear relationship to verify Kepler's third law.
CON-6.D Calculate the gravitational potential energy and the kinetic energy of a satellite/ Earth system in which the satellite is in circular orbit around the earth.
CON-6.E Derive the relationship of total mechanical energy of a satellite/earth system as a function of radial position.
CON-6.F a. Derive an expression for the escape speed of a satellite using energy principles. b. Describe the motion of a satellite launched straight up (or propelled toward the planet) from the planet's surface, using energy principles.
CON-6.G Calculate positions, speeds, or energies of a satellite launched straight up from the planet's surface, or a satellite that is projected straight toward the planet's surface, using energy principles
CON-6.H Describe elliptical satellite orbits using Kepler's three laws of planetary motion.

CON-6.I a. Calculate the orbital distances and velocities of a satellite in elliptical orbit using the conservation of angular momentum. b. Calculate the speeds of a satellite in elliptical orbit at the two extremes of the elliptical orbit (perihelion and aphelion).

<table>
<tr><th colspan="3">Unit 1: Kinematics</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">

- **CHA-1**
- **CHA-2**

</td><td colspan="2">

- *Graphs, equations and diagrams can be used to model and predict motion. Calculus provides tools to analyze complex motion.*

</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>

- *Motion can only be defined relative to an arbitrary frame of reference. Reference frames can be inertial or non-inertial.*
- *Graphs and equations can be used to model and predict motion. Calculus gives us tools for analyzing non-linear graphs.*
- *Two-dimensional motion can be broken into perpendicular components that are independent of each other. Because of this, one dimensional models can be used to analyze any two dimensional motion, such as circular or projectile motion.*

</td><td>

- *How can we model and predict the motion of an object?*
- *How can calculus be used to model and analyze complex motion?*
- *How do we model two-dimensional motion, such as circular motion?*

</td></tr>
</table>

Learning Targets
Students will… ● ***Understand the general relationships among position, velocity and acceleration for the motion of a particle along a straight line.*** ● ***Understand the general motion of a particle in two dimensions so that, given functions of components (x and y or radial and tangential) which describe this motion, they can determine the components, magnitude, and direction of the particle's velocity and acceleration as functions of time.*** ● ***Given a graph of one of the kinematic quantities, position, velocity or acceleration, as a function of time, they can identify or sketch a graph of the others as a function of time. (Special attention to max/min, and intercept values.)*** ● ***Given an expression for one of the kinematic quantities, position, velocity or acceleration, as a function of time, they can determine the other two as a function of time, and find when these quantities are zero or achieve their maximum and minimum values.*** ● ***Know how to deal with situations in which acceleration is a specified function of velocity and time so they can write an appropriate differential equation and solve it for v(t) by separation of variables, correctly incorporating a given initial value of v . (e.g. air resistance)*** ● ***Be able to add, subtract, and resolve displacement, velocity and acceleration vectors.*** ● ***Describe qualitatively, with the aid of graphs, the acceleration, velocity, and displacement of such a particle when it is released from rest or is projected vertically with specified initial velocity under the influence of drag.***
Unit Duration:
6 weeks (revisiting throughout year)

<table>
<tr><th colspan="3"> 
Unit 2: Newton’s Laws of Motion</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">INT-1
INT-2
INT-3</td><td colspan="2">Newton’s Laws describe the relation between forces and motion.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>An object’s acceleration is proportional to the net force acting on it and inversely proportional to the mass of the object.
For every action there is an equal and opposite reaction.</td><td>What are forces?
What factors affect acceleration?
How do systems affect each other?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
Understand the relation between the force that acts on an object and the resulting change in the object’s velocity. S
Understand how Newton’s Second Law, EF = m x a, applies to an object subject to forces such as gravity, the pull of strings, or contact forces.
Understand the significance of the coefficient of friction in both the kinetic and static cases.
Understand the effect of drag forces (air resistance) on the motion of an object.
Understand Newton’s Third Law so that, for a given system, they can identify the force pairs and the objects on which they act, and state the magnitude and direction of each force.
Calculate, for an object moving in one or two dimensions, the velocity change that results when a constant force F, or a varying force F(t) acts over a specified time interval.</td></tr>
</table>

- ***Draw a well-labeled, free-body diagram showing all real forces that act on the object, so that they can write the summation statements for the net force in each component. Use those summation statements to solve for unknown forces or accelerations. Also, problems involving multiple objects requiring a system of equations.***
- ***Analyze situations in which an object moves with specified acceleration under the influence of one or more forces so they can determine the net force or of one of the forces that makes up the net force.***
- ***Write down the relationship between the normal and frictional forces on a surface, so they might analyze situations in which an object moves along a rough surface or under what circumstances an object will start to slip, or to calculate the magnitude of the force of static friction.***
- ***Find the terminal velocity of an object moving vertically under the influence of a drag force dependent on velocity. Or use Newton's 2nd to write and solve the differential equation for the velocity of a function of time.***
- ***Understand the uniform circular motion of a particle and distinguish between circular motion and rotation.***

Unit Duration:

4 weeks (revisiting throughout year)

<table>
<tr><th colspan="3">Unit 3: Work, Energy and Power</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● INT-4
● CON-1
● CON-2
● CON-3</td><td colspan="2">● Energy can be transferred or stored in a variety of ways, but never created or destroyed.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Energy cannot be created or destroyed, only transferred from one form or system to another.
● Work is the process of transferring energy using a force</td><td>● What is energy and how is it stored and transferred?
● What does it mean for a machine to be powerful?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Understand conservation of energy and can identify how energy is being stored within a given system. (kinetic, gravitational, elastic, chemical, dissipated, etc.)
● Understand the definition of work, including when it is positive, negative, or zero.
● State the general relation between force and potential energy, and explain why potential energy can be associated only with conservative forces.
● Use diagrams (bar graphs, pie charts) to model the transfer and storage of energy in a system.
● Apply conservation of energy to analyze systems involving multiple bodies or systems under the influence of constant and/or non constant forces.
● Calculate the work done using the dot product of force and displacement for a constant force, or using the area under a force vs. position graph (integral of F(x)) for a varying force.
● Calculate a potential energy function associated with a specified one-dimensional force F(x). (Or the reverse.)
● Calculate the power needed to produce specified motion or use power to calculate the quantity of work being done.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">6 weeks</td></tr>
</table>

Unit 4: Systems of Particles and Linear Momentum

Standards	Transfer Goal(s) /Big Ideas	
● **CHA-3** ● **INT-5** ● **CON-4**	● ***Momentum is a conserved quantity that is useful in analyzing collisions and explosions.***	
	Enduring Understandings	**Essential Questions**
	● ***The total momentum in a closed system is conserved.*** ● ***The linear motion of an extended body can be approximated by treating the body as a point particle located at the center of mass.*** ● ***Impulse is the change in momentum caused by a force.***	● *How do accident investigators determine the speed of cars before a collision?* ● *How can we analyze the motion of groups of particles?*

Learning Targets

Students will…

- ***Understand and apply the relation between center-of-mass velocity and linear momentum, and between center-of-mass acceleration and net external force for a system of particles.***
- ***Understand impulse and linear momentum.***
- ***Explain how linear momentum conservation follows as a consequence of Newton's Third Law for an isolated system.***
- ***Understand under what conditions momentum is conserved.***
- ***Understand the technique for finding center of mass, so they can, by inspection, find the center of mass of a symmetrical object or, by formula, locate the center of mass of a system consisting of two or more objects or use integration to find the center of mass of a thin rod of nonuniform density***

● ***Determine the impulse on a system by determining the change in momentum, by multiplying the average force by time, by determining the area under a force vs. time graph or by integrating a function F(t).*** ● ***Apply linear momentum conservation to one-or two-dimensional elastic and inelastic collisions or explosions.***
Unit Duration:
4 weeks

<table>
<tr><th colspan="3"> 
Unit 5: Rotation</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● INT-6
● CHA-4
● INT-7
● CON-5</td><td colspan="2">● Rotation can be analyzed using quantities that are analogous to translational quantities. Most rotational equations have the same form as their translational counterparts.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● For rotating bodies, the angle is analogous to position for a translating body. Other linear quantities have rotational analogs.
● Angular momentum is conserved in a closed system.
● A rotating object has kinetic energy even if it is not translating.</td><td>● How can we model objects that spin or move in circles?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
● Understand the uniform circular motion of a particle and distinguish between circular motion and rotation.
● Develop a qualitative understanding of rotational inertia so they can determine which of a set of symmetrical objects of equal mass has the greatest rotational inertia or by what factor an object’s rotational inertia changes if all its dimensions are increased by the same factor.
● Understand the analogy between translational and rotational kinematics so they can write and apply relations among the angular acceleration, angular velocity, and angular displacement of an object that rotates about a fixed axis with constant angular acceleration.
● Write down, justify, and apply the relation between linear and angular velocity, or between linear and angular acceleration, for an object of circular cross section that rolls with or without slipping along a fixed plane, and determine the velocity and acceleration of an arbitrary point on such an object.</td></tr>
</table>

- ***Understand angular momentum conservation, so they can recognize the conditions under which this law is applicable and relate this law to one- and two-particle systems such as satellite orbits.***
- ***Analyze the equilibrium of a rigid object under the combined influence of a number of coplanar forces applied at different locations.***
- ***Compute the rotational inertia of a collection of point masses lying in a plane, or of any uniform bodies or collection of uniform bodies (i.e. rod, sphere, hoop, etc.). Understand and apply the parallel axis theorem when needed.***
- ***Determine the angular acceleration for a rigid object when subjected to a specified external torque or force. Also, determine the centripetal and tangential acceleration of any point on that body.***
- ***Apply conservation of energy to problems of fixed-axis rotation or the problems involving a rolling body.***
- ***Calculate the angular momentum vector for a moving particle and for a rotating rigid object about a fixed axis.***
- ***Use conservation of angular momentum to analyze problems in which the moment of inertia of an object is changed as it rotates and a collision between a moving particle and a rigid object that can rotate about a fixed axis.***

Unit Duration:

6 weeks

Unit 6: Simple Harmonic Motion

Standards	Transfer Goal(s) /Big Ideas	
● **INT-8**	● ***The period of an object in Simple Harmonic Motion can be determined from the physical characteristics of the system.***	
	Enduring Understandings	**Essential Questions**
	● ***Simple Harmonic Motion (SHM) occurs when the force on a particle is proportional to its displacement, but acts in the opposite direction.*** ● ***SHM can be modeled with a sine function.***	● *How do we analyze systems with repeating motion, such as a mass hanging on a spring or a swinging pendulum?*

Learning Targets

Students will…

- ***Recognize that a system that obeys a differential equation of the form must execute simple harmonic motion, and determine the frequency and period of such motion.***
- ***Develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force.***
- ***Apply their knowledge of simple harmonic motion to the case of a mass on a spring and to simple, physical, or torsional pendulums.***
- ***Sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude, period, and frequency of the motion. Be able to write an equation that models such a graph.***
- ***State the relations between acceleration, velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values. Use this relation to write functions for velocity and acceleration.***
- ***Calculate the kinetic and potential energies of an oscillating system as functions of time, sketch or identify graphs of these functions, and prove that the sum of kinetic and potential energy is constant. Use these graphs or functions to determine the maximum displacement or velocity.***

● ***Use the physical characteristics of the system to derive and apply the expressions for the period of a mass on a spring, and for various types of pendulums (simple, torsional, physical). Understand the approximations that must be made to write these expressions.***
Unit Duration:
6 weeks

<table>
<tr><th colspan="3"> 
Unit 7: Gravitation</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">FLD-1
CON-6</td><td colspan="2">The characteristics of a stable orbit are based on the mass of the central body and the velocity and radius of the orbiting body.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>The force of gravity exists between any two masses, and is proportional to these masses and inversely proportional to the square of the distance between them.</td><td>How do we model the orbits of planets and moons?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
Describe the gravitational force inside and outside a uniform sphere, and calculate how the field at the surface depends on the radius and density of the sphere.
For circular orbits, recognize that the motion does not depend on the object’s mass; describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and derive expressions for the velocity and period of revolution in such an orbit.
Derive Kepler’s 3rd Law for circular orbits and understand how to apply it to elliptical orbits.
Apply conservation of angular momentum to determine the velocity and radial distance at any point in the orbit.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">3 weeks</td></tr>
</table>

Strand: Experimental Design and Analysis (AP Practices 2,3,4,7)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** ● 2.A Identify a testable scientific question or problem. ● 2.B Make a claim or predict the results of an experiment. ● 2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup). ● 2.D Make observations or collect data from representations of laboratory setups or results. ● 2.E Identify or describe potential sources of experimental error. ● 2.F Explain modifications to an experimental procedure that will alter results ● 3.A Select and plot appropriate data. ● 3.B Represent features of a model or the behavior of a physical system using appropriate graphing techniques, appropriate scale, and units. ● 3.C Sketch a graph that shows a functional relationship between two quantities. ● 4.A Identify and describe patterns and trends in data or a graph. ● 4.B Demonstrate consistency between different graphical representations of the same physical situation. ● 4.C Linearize data and/or determine a best fit line or curve. ● 4.D Select relevant features of a graph to describe a physical situation or solve problems. ● 7.A Make a scientific claim. ● 7.B Support a claim with evidence from experimental data.		● Students will be designing and carrying out experiments. ● Students will look at sample data/graphs and describe possible reasons for error in the results. ● Students will report sources of error and analyze their own results. ● Students will analyze their own experimental results. ● Students will conduct experiments and analyze the results. They will present their findings to the class and defend their conclusions. ● Students will ask questions in a Socratic format to understand/evaluate the models of other students. ● Students will answer lab questions explaining and defending their model.

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	● 7.E Explain the connection between experimental results and larger physical principles, laws, or theories. ● 7.F Explain how potential sources of experimental error may affect results and/or conclusions **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Students will read descriptions of experimental procedures and determine if the experiment is valid and identify the independent/dependent variables. ● Students will practice making and analyzing graphs using Vernier Graphical Analysis software.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit I Kinematics (CHA-1,CHA-2)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** ● CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration. ● CHA-1.B Determine functions of position, velocity, and acceleration that are consistent with each other, for the motion of an object with a nonuniform acceleration. ● CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. ● CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference.		● Students will take data for a cart rolling down an incline and relate the time it takes for a cart to travel to the change in speed of the car, i.e. acceleration. ● Homework solutions will be discussed / presented to the class using white boards. ● Using video analysis software, students will examine 2-dimensional motion on Angry Bird World and compare/contrast the gravitational force and trajectory of a projectile on A.B. World to that of Earth. ● Students will use physics principles and algebra to derive the Range equation which combines horizontal and vertical motion quantities for a projectile. ● Homework solutions will be discussed / presented to the class using white boards.

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	● CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations. ● CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory. ● CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit 2: Newton's Laws (INT-1, INT-2, INT-3)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** ● INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks). ● INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium. ● INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines). ● INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.). ● INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional		● Students will perform a lab using Atwood's machine to determine what factors affect its acceleration. ● Homework solutions will be discussed / presented to the class using white boards. ● Students will examine springs that are hooked together in series vs. parallel and understand why they (the two methods) result in different spring constants.

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	relationship in different physical situations (e.g., object sliding on surface or object not slipping on incline). ● INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations. ● INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on truck bed, an object at rest on incline, or an object pinned to a horizontal surface). ● INT-1.H a. Derive an expression for the motion of an object freely falling with a resistive drag force (or moving horizontally subject to a resistive horizontal force). b. Describe the acceleration, velocity, or position in relation to time for an object subject to a resistive force (with different initial conditions, i.e., falling from rest or projected vertically). ● INT-1.I Calculate the terminal velocity of an object moving vertically under the influence of a resistive force of a given relationship. ● INT-1.J a. Derive a differential equation for an object in motion subject to a specified resistive force. b. Derive an expression for a time-dependent velocity function for an object moving under the influence of a given resistive force (with given initial conditions). c. Derive expressions for the acceleration or position of an object moving under the influence of a given resistive force. ● INT-2.A a. Calculate the velocity of an object moving in a horizontal circle with a constant speed, when subject to a known centripetal force. b. Calculate relationships among the radius of a circle, the speed of an object (or period of revolution), and the magnitude of centripetal acceleration for an object moving in uniform circular motion. ● INT-2.B a. Explain how a net force in the centripetal direction can be a single force, more than one force, or even components of forces that	

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	are acting on an object moving in circular motion. b. Describe forces that are exerted on objects undergoing horizontal circular motion, vertical circular motion, or horizontal circular motion on a banked curve. c. Describe forces that are acting on different objects traveling in different circular paths. ● INT-2.C a.Describe the direction of the velocity and acceleration vector for an object moving in two dimensions, circular motion, or uniform circular motion. b. Calculate the resultant acceleration for an object that changes its speed as it moves in a circular path. ● INT-2.D Derive expressions relating centripetal force to the minimum speed or maximum speed of an object moving in a vertical circular path. ● INT-2.E Derive expressions relating the centripetal force to the maximum speed of an object or minimum speed of an object moving in a circular path on a banked surface with friction. ● INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords). ● INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys). **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations.	

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit 3 Work,Energy and Power (INT-4, CON-1, CON-2, CON-3)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** ● INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero. ● INT-4.B Calculate a value for work done on an object from a force versus position graph. ● INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces. ● CON-1.A a. Compare conservative and dissipative forces. b. Describe the role of a conservative force or a dissipative force in a dynamic system. ● CON-1.B a. Explain how the general relationship between potential energy functions and conservative forces is used to determine relationships between the two physical quantities. b. Derive an expression that represents the relationship between a conservative force acting in a system on an object to the potential energy of the system using the methods of calculus.		● Students will examine how energy changes form within a closed system and then, using the same system, see how work is done if it is left 'open' / objects are removed from the system. ● Homework solutions will be discussed / presented to the class using white boards. ● Students will use calculus to determine the potential energy function if given the force function and vice versa. (e.g. elastic energy.) ● Students will analyze videos to determine whether or not energy is conserved or if work is being done to the object in the video.

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	● CON-1.C Describe the force within a system and the potential energy of a system ● CON-1.D a. Derive the expression for the potential energy function of an ideal spring. b. Derive an expression for the potential energy function of a nonideal spring that has a nonlinear relationship with position. ● CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field. ● CON-1.F Derive an expression for the gravitational potential energy of a system consisting of a satellite or large mass (e.g., an asteroid) and the Earth at a great distance from the Earth. ● CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant. ● CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a “conservative” mechanical system. ● CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force. ● CON-2.D Derive expressions such as positions, heights, angles, and speeds for an object in vertical circular motion or pendulum motion in an arc.	

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	● CON-3.A a. Derive an expression for the rate at which a force does work on an object. b. Calculate the amount of power required for an object to maintain a constant acceleration. c. Calculate the amount of power required for an object to be raised vertically at a constant rate. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit 4 Systems of Particles and Linear Momentum (CHA-3, INT-5, CON-4)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** **The student exhibits no major errors or omissions.** ● CHA-3.A a. Calculate the center of mass of a system of point masses or a system of regular symmetrical objects. b. Calculate the center of mass of a thin rod of nonuniform density using integration ● CHA-3.B Describe the motion of the center of the mass of a system for various situations. ● CHA-3.C Explain the difference between the terms “center of gravity” and “center of mass,” and identify physical situations when these terms have identical positions and when they have different positions. ● INT-5.A a. Calculate the total momentum of an object or a system of objects. b. Calculate relationships between mass, velocity, and linear momentum of a moving object. ● INT-5.B Calculate the quantities of force, time of collision, mass, and change in velocity from an expression relating impulse to change in linear momentum for a collision of two objects. ● INT-5.B Calculate the quantities of force, time of collision, mass, and change in velocity from an expression relating impulse to change in linear momentum for a collision of two objects. ● INT-5.D Calculate the momentum change in a collision using a force versus time graph for a collision.		● Students will analyze videos and investigate what happens to the C.O.M. of objects when an external unbalanced force is and is NOT present. ● Homework solutions will be discussed / presented to the class using white boards ● Different in class demonstrations (such as jumping and landing w/out bending your knees) will be presented so that students can understand the relationship between F & t during an impulse. ● Students will conduct a laboratory investigation where carts are crashed into one another on a track. The data will be analyzed to figure out when momentum(and energy) is and is NOT conserved during a collision.

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	● INT-5.E Calculate the change in momentum of an object given a nonlinear function, F(t), for a net force acting on the object. ● CON-4.A a. Calculate the velocity of one part of a system after an explosion or a collision of the system. b. Calculate energy changes in a system that undergoes a collision or an explosion. ● CON-4.B Calculate the changes of momentum and kinetic energy as a result of a collision between two objects. ● CON-4.C Describe the quantities that are conserved in a collision. ● CON-4.D Calculate the speed of the center of mass of a system. ● CON-4.E a. Calculate the changes in speeds, changes in velocities, changes in kinetic energy, or changes in momenta of objects in all types of collisions (elastic or inelastic) in one dimension, given the initial conditions of the objects. b. Derive expressions for the conservation of momentum for a particular collision in one dimension. ● CON-4.F a. Calculate the changes in speeds, changes in velocities, changes in kinetic energy, or changes in momenta of objects involved in a two-dimensional collision (including an elastic collision), given the initial conditions of the objects. b. Derive expressions for the conservation of momentum for a particular two-dimensional collision of two objects.	
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		

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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Strand: AP Unit 5 Rotation (INT-6 , CHA-4, INT-7, CON-5)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● INT-6.A a. Calculate the magnitude and direction of the torque associated with a given force acting on a rigid body system. b. Calculate the torque acting on a rigid body due to a gravitational force. ● INT-6.B a. Describe the two conditions of equilibrium for an extended rigid body. b. Calculate unknown magnitudes and directions of forces acting on an extended rigid body that is in a state of translational and rotational equilibrium. ● INT-6.C a. Explain the differences in the moments of inertia between different objects such as rings, discs, spheres, or other regular shapes by applying the general definition of moment of inertia (rotational inertia) of a rigid body. b. Calculate by what factor an object's rotational inertia will change when a dimension of the object is changed by some factor c. Calculate the moment of inertia of point masses that are located in a plane about an axis perpendicular to the plane. ● INT-6.D a. Derive the moment of inertia, using calculus, of a thin rod of uniform density about an arbitrary axis perpendicular to the rod. b. Derive the moment of inertia, using calculus, of a thin rod of nonuniform density about an arbitrary axis perpendicular to the rod. c. Derive the moments of inertia for a thin cylindrical shell or disc about		● Students will derive circular motion equations by examining the centripetal force and acceleration of a stopper that is spun overhead. ● Homework solutions will be discussed / presented to the class using white boards ● Students will examine the relationship between known force and balancing force while investigating torque for an object in static equilibrium. ● Class discussion will be held to differentiate between vector and scalar quantities as well as the difference between the 'Dot Product' vs. 'Cross Product' of two vectors. ● Students will use the Right Hand Rule to find the correct direction for the cross product of two vectors. ● Students will analyze videos of rotating objects and draw parallels between translational and rotational motion.

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	its axis or an object that can be considered to be made up of coaxial shells (e.g. annular ring). ● INT-6.E Derive the moments of inertia of an extended rigid body for different rotational axes (parallel to an axis that goes through the object's center of mass) if the moment of inertia is known about an axis through the object's center of mass ● CHA-4.A a. Explain how the angular kinematic relationships for uniform angular acceleration are directly analogous to the relationships for uniformly and linearly accelerated motion. b. Calculate unknown quantities such as angular positions, displacement, angular speeds, or angular acceleration of a rigid body in uniformly accelerated motion, given initial conditions. c. Calculate unknown quantities such as angular positions, displacement, angular velocity, or rotational kinetic energy of a rigid body rotating with a specified non uniform angular acceleration. ● CHA-4.B a. Explain the use of the relationships that connect linear translational motion to rotational motion in appropriate physical situations. b. Calculate the translational kinematic quantities from an object's rotational kinematic quantities for objects that are rolling without slipping. c. Calculate the (tangential) linear acceleration of a point on a rotating object given the object's angular acceleration. ● INT-7.A a. Describe the complete analogy between fixed axis rotation and linear translation for an object subject to a net torque. B. Calculate unknown quantities such as net torque, angular acceleration, or moment of inertia for a rigid body undergoing rotational acceleration. c. Calculate the angular acceleration of an extended rigid body, of known moment of inertia, about a fixed axis or about its center of mass when it is experiencing a specified net torque due to one of several applied forces.	● Students will analyze videos of objects to determine whether or not angular momentum is conserved.

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	● INT-7.B a. Describe the net torque experienced by a rigid extended body in situations such as, but not limited to, rolling down inclines, pulled along horizontal surfaces by external forces, a pulley system (with rotational inertia), simple pendulums, physical pendulums, and rotating bars. b. Derive an expression for all torques acting on a rigid body in various physical situations using Newton's second law of rotation. ● INT-7.C Derive expressions for physical systems such as Atwood machines, pulleys with rotational inertia, or strings connecting discs or strings connecting multiple pulleys that relate linear or translational motion characteristics to the angular motion characteristics of rigid bodies in the system that are (a) rolling (or rotating on a fixed axis) without slipping. (b) rotating and sliding simultaneously. ● INT-7.D a.Calculate the rotational kinetic energy of a rotating rigid body. B. Calculate the total kinetic energy of a rolling body or a body that has both translational and rotational motions. c. Calculate the amount of work done on a rotating rigid body by a specified force applied to the rigid body over a specified angular displacement. ● INT-7.E Derive expressions using energy conservation principles for physical systems such as rolling bodies on inclines, Atwood machines, pendulums, physical pendulums, and systems with massive pulleys that relate linear or angular motion characteristics to initial conditions (such as height or position) or properties of rolling body (such as moment of inertia or mass). ● CON-5.A a. Calculate the angular impulse acting on a rotating rigid body given specified angular properties or forces acting over time intervals. b. Calculate the angular momentum vector of a rotating rigid body in cases in which the vector is parallel to the angular velocity vector.	

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	● CON-5.B Calculate the angular momentum vector of a linearly translating particle about a defined stationary point of reference ● CON-5.C a. Describe the conditions under which a rotating system's angular momentum is conserved. b. Explain how a one- or two-particle system (rotating object or satellite orbits) may have a change in angular velocity when other properties of the system change (such as radius or inertia) ● CON-5.D a. Calculate changes in angular velocity of a rotating rigid body when the moment of inertia of the body changes during the motion (such as a satellite in orbit). b. Calculate the increase or decrease in angular momentum of a rigid body when a point mass particle has a collision with the rigid body. c. Calculate the changes of angular momentum of each disc in a rotating system of two rotating discs that collide with each other inelastically about a common rotational axis. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit 6 Simple Harmonic Motion (INT-8)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** ● INT-8.A a. Describe the general behavior of a spring-mass system in SHM in qualitative terms. b. Describe the relationship between the phase angle and amplitude in an SHM system. ● INT-8.B a. Describe the displacement in relation to time for a mass-spring system in SHM. b. Identify the period, frequency, and amplitude of the SHM in a mass-spring system from the features of a plot. ● INT-8.C Describe each of the three kinematic characteristics of a spring-mass system in SHM in relation to time (displacement, velocity, and acceleration). For a spring-mass system in SHM— a. describe the general features of the motion and b. identify the places on a graph where these values are zero or have maximum positive values or maximum negative values. ● INT-8.D Derive a differential equation to describe Newton's second law for a spring-mass system in SHM or for the simple pendulum. ● INT-8.E Calculate the position, velocity, or acceleration of a spring-mass system in SHM at any point in time or at any known position from the initial conditions and known spring constant and mass		● Students will conduct an experiment to determine what factors affect the period of a simple pendulum. ● Students will analyze videos of a mass on a spring in SHM to determine the relationship between period, mass and spring constant. ● Students will analyze videos of objects exhibiting SHM to determine the shapes of position, velocity and acceleration vs time graphs. ● Lecture on solving differential equations and what forms of equations model SHM.

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	● INT-8.F Derive the expression for the period of oscillation for various physical systems oscillating in SHM. ● INT-8.G Calculate the mechanical energy of an oscillating system. Show that this energy is conserved in an ideal SHM spring-mass system. ● INT-8.H Describe the effects of changing the amplitude of a spring-mass system. ● INT-8.I Describe the kinetic energy as a function of time (or position), potential energy as a function of time (or position), and total mechanical energy as a function of time (or position) for a spring-mass system in SHM, identifying important features of the oscillating system and where these features occur. ● INT-8.J Explain how the model of SHM can be used to determine characteristics of motion for other physical systems that can exhibit this behavior. ● INT-8.K Describe a linear relationship between the period of a system oscillating in SHM and physical constants of the system. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: AP Unit 7 Gravitation (FLD-1, CON-6)			
Grade: 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● FLD-1.A Calculate the magnitude of the gravitational force between two large spherically symmetrical masses ● FLD-1.B Calculate the value for g or gravitational acceleration on the surface of the Earth (or some other large planetary object) and at other points outside of the Earth. ● FLD-1.C Describe the motion in a qualitative way of an object under the influence of a variable gravitational force, such as in the case where an object falls toward the Earth's surface when dropped from distances much larger than the Earth's radius. ● CON-6.A Calculate quantitative properties (such as period, speed, radius of orbit) of a satellite in circular orbit around a planetary object. ● CON-6.B Derive Kepler's third law for the case of circular orbits. ● CON-6.C Describe a linear relationship to verify Kepler's third law.		● Lecture on Newton's Law of gravitation. ● Students compare circular to elliptical orbits, determine if/when speed is constant and why. ● Lecture on Kepler's Laws and their derivations for circular orbits.

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	● CON-6.D Calculate the gravitational potential energy and the kinetic energy of a satellite/ Earth system in which the satellite is in circular orbit around the earth. ● CON-6.E Derive the relationship of total mechanical energy of a satellite/earth system as a function of radial position. ● CON-6.F a. Derive an expression for the escape speed of a satellite using energy principles. b. Describe the motion of a satellite launched straight up (or propelled toward the planet) from the planet's surface, using energy principles. ● CON-6.G Calculate positions, speeds, or energies of a satellite launched straight up from the planet's surface, or a satellite that is projected straight toward the planet's surface, using energy principles ● CON-6.H Describe elliptical satellite orbits using Kepler's three laws of planetary motion. ● CON-6.I a. Calculate the orbital distances and velocities of a satellite in elliptical orbit using the conservation of angular momentum. b. Calculate the speeds of a satellite in elliptical orbit at the two extremes of the elliptical orbit (perihelion and aphelion). **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Students understand basic concepts described above and can apply them in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

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Honors Physics ***Course Overview***	
Grade level(s): 11th - 12th	**Credits earned:** (Science) 1 Unit
Course Rationale	**Course Description**
Scientists use experiments to investigate the universe by collecting data to create mathematical models to explain and predict what they see. This course will help students develop the skills needed to be scientists. Students seeking careers in the STEM fields will need the skills taught in honors physics to be successful in these fields.	*This course is designed to prepare students for AP Physics in their senior year. The first year will cover mechanics, which includes such topics as motion, forces, energy, and momentum. There is an emphasis on laboratory investigations and problem solving.*
Transfer Goals/Big Ideas	
● Asking Questions and Defining Problems ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information	
Priority Missouri Learning Standards/National Standards	
From National AP Physics Standards (College Board) **Science Practices** 2: Question and Method: Determine scientific questions and methods. 2.A Identify a testable scientific question or problem.	

2.B Make a claim or predict the results of an experiment.
2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup).
2.D Make observations or collect data from representations of laboratory setups or results.
2.E Identify or describe potential sources of experimental error.
3: Representing Data and Phenomenon: Create visual representations or models of physical situations.
3.A Select and plot appropriate data.
3.C Sketch a graph that shows a functional relationship between two quantities.
4: Data and Analysis: Analyze quantitative data represented in graphs.
4.A Identify and describe patterns and trends in data or a graph.
4.C Linearize data and/or determine a best fit line or curve.
7: Argumentation: Develop an explanation or a scientific argument
7.A Make a scientific claim.
7.B Support a claim with evidence from experimental data.
7.F Explain how potential sources of experimental error may affect results and/or conclusions

Content Standards

CHA-1 There are relationships among the vector quantities of position, velocity, and acceleration for the motion of a particle along a straight line
CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration.
CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.
CHA-2 There are multiple simultaneous relationships among the quantities of position, velocity, and acceleration for the motion of a particle moving in more than one dimension with or without net forces
CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference.
CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations.
CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory.

CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time.

INT-1 A net force will change the translational motion of an object.

INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks).

INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium.

INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines).

INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.).

INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional relationship in different physical situations (e.g., object sliding on surface or object not slipping on incline).

INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations.

INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on truck bed, an object at rest on incline, or an object pinned to a horizontal surface).

INT-3 There are force pairs with equal magnitude and opposite directions between any two interacting objects.

INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords).

INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys).

INT-4 When a force is exerted on an object, and the energy of the object changes, then work was done on the object.

INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero. (In honors physics, only constant forces will be addressed.)
INT-4.B Calculate a value for work done on an object from a force versus position graph.
INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces.
CON-1 Conservative forces internal to the system can change the potential energy of that system.
CON-1.D a. Derive the expression for the potential energy function of an ideal spring.
CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field.
CON-2 The energy of a system can transform from one form to another without changing the total amount of energy in the system.
CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant.
CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a "conservative" mechanical system.
CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force.

Unit 1: Experimental Methods
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**	
● Practice 2A,B,C,D,E ● Practice 3 A,B,C ● Practice 4 A,C ● Practice 7 A,B,F	● *Scientists use experiments to investigate the universe.*	
	Enduring Understandings	**Essential Questions**
	● ***Scientists use experiments to investigate the universe. They use the data collected to create mathematical models to explain and predict what they see. Scientists must be able to explain their work and defend it if it is going to be accepted as "true."***	● **How do scientists design experiments?** ● **How do scientists determine if something is "true"?** ● **How and why do scientists model what happens in the real world?**

Learning Targets

Students will…

- *Design and conduct a valid experiment to answer a question.*
- *Describe possible sources of experimental error and suggest ways to adjust the procedure to minimize this error.*
- *Analyze data using graphs and appropriate software to determine the relationship between variables. Students should be able to describe several types of relationships (linear, proportional, quadratic and inverse) verbally, graphically and mathematically.*
- *Explain the connection between their data and graphs to the overall model (mathematical, graphical, verbal) of a given system. They can describe this connection in class discussions and in written form and use these models to predict future behavior.*

Unit Duration:

Year long. This unit will focus on the basics of designing, conducting and analyzing experiments. Students will be implementing these standards in every unit for the duration of the course.

<table>
<tr><th colspan="3"> 
Unit 2: Kinematics (1-D and 2-D motion)
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard)

● CHA-1
● CHA-2</td><td colspan="2">● Graphs, equations and diagrams can be used to model and predict motion.</td></tr>
<tr><td>Enduring Understandings

● Motion can only be defined relative to an arbitrary frame of reference.
● A vector is a quantity that incorporates direction.
● Graphs and equations can be used to model and predict motion.
● The vertical and horizontal components of the motion of a projectile are independent of each other. Because of this, one dimensional models can be used to analyze two dimensional projectile motion.
● Bodies in free fall have the same acceleration regardless of mass.</td><td>Essential Questions

● How can we model and predict the motion of an object?
● What is acceleration?
● Do heavier things fall faster?
● How can graphs be used to model and analyze motion?
● How do we model 2-dimensional motion?</td></tr>
</table>

Learning Targets
Students will… ● *Break a 2D vector into components, or given components can find the magnitude and direction.* ● *Add any two vectors together.* ● *Students can model 1-D motion with various graphs, equations and diagrams.* ● *Given a motion graph (x vs t, v vs t, a vs t) students can sketch the other two graphs and describe the motion being modeled .* ● *Correctly use the kinematic equations in problem solving, including free fall situations.* ● *Solve problems involving projectiles launched at any angle from the ground or launched horizontally from any height. (Can predict range, launch velocity, etc.)*
Unit Duration:
These standards will be split into multiple units, taught over several months. The first part of this unit will cover 1-D motion for objects moving with a constant velocity. The 2nd part will cover accelerated motion including objects in free fall. This unit concludes with 2-D motion.

<table>
<tr><th colspan="3"> 
Unit 3: Newton's Laws
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">INT-1
INT-3</td><td colspan="2">A force is needed to change the motion of an object (accelerate), not to cause motion. This acceleration is related to the net force and mass of the system.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>A force is an interaction between two objects that affects both objects equally. (Newton's 3rd)
A force is needed to change the motion of an object, not to cause motion. (Newton's 1st)
Acceleration occurs only when a net force acts on a system. The acceleration is proportional to the force and inversely proportional to the mass of the system. (Newton's 2nd)</td><td>What are forces and what do they do?
What causes acceleration?
What factors affect this acceleration?
What is equilibrium and how can we determine if something is in equilibrium?</td></tr>
</table>

Learning Targets
Students will… ● *Understand that a force is an interaction between two objects that can result in acceleration.* ● *Understand that the net force affects the motion of an object and can use the net force to predict if the object accelerates.* ● *Understand that tension and normal forces occur as the result of distortions (stretches/compressions) of an object.* ● *Understand the concept of coefficient of friction and can differentiate between static and kinetic friction.* ● *Identify when various types of forces (gravity, friction, normal, tension) occur and the direction they act.* ● *Understand the difference between mass and weight and can calculate one if given the other.* ● *State Newton's 3rd Law and can use it to explain situations such as why a rocket rises or how we walk.* ● *Use the expression Ff = mu x Fn to calculate the force of friction, understanding when to use the inequality/equality.* ● *Understand Hooke's Law and use this law to calculate tension, spring constant or distortion.* ● *Use Newton's 1st and 2nd Law to predict the motion of objects or can use the motion to find the value of the forces needed to produce it.* ● *Draw a force diagram to represent the individual forces that act on a system.* ● *Write summation statements to represent the net force acting on an object in the x and y directions.* ● *Give the Newton's 3rd law pair force for any given force.* ● *Apply Newton's 3rd Law to problem solving involving multiple objects.*
Unit Duration:
The strand will be split into 2 units, covered over a couple months.

Unit 4: Work and Energy
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● INT-4
● CON-1
● CON-2</td><td colspan="2">● Energy cannot be created or destroyed, only transferred.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Energy can be stored in various ways and can be transferred from system to system, but the total amount always remains the same.
● Work is the transfer of energy from system to system via a force.</td><td>● How can energy be stored and what does it do?
● How can energy be moved from place to place?
● What characteristics of a system show energy is stored there?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Understand that work is the transfer of energy into or out of a system by means of a force and can identify situations in which work is done.
● State the Law of Conservation of Energy.
● Distinguish open and closed systems and when work is/is not done.
● Identify energy storage and changes within a system and represent this change with a diagram (pie chart or bar graph.)
● Use formulae to correctly calculate the amount of energy stored.
● Calculate the work done by using the relation W = F x d x cos(theta) or by using the area under a force vs. position graph.
● Use the law of conservation of energy, and the concept of work to predict the behavior/characteristics of objects in an open or closed system.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">2-4 weeks.</td></tr>
</table>

Strand: Experimental Methods, Practices 2, 3, 4, 7		
Grade: 11th-12th		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**
	3.5 In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** 2.A Identify a testable scientific question or problem. 2.B Make a claim or predict the results of an experiment. 2.C Identify appropriate experimental procedures (which may include a sketch of a lab setup). 2.D Make observations or collect data from representations of laboratory setups or results. 2.E Identify or describe potential sources of experimental error. ● Given a system to analyze, students can design and carry out a valid experiment to model the situation. This includes choosing an appropriate range of values for the independent variable and taking a sufficient number of trials. ● They can clearly describe the purpose and procedure of their experiment in a written report. 3.A Select and plot appropriate data. 3.C Sketch a graph that shows a functional relationship between two quantities. 4.A Identify and describe patterns and trends in data or a graph. 4.C Linearize data and/or determine a best fit line or curve. ● Will analyze their own lab results to determine the specific relationship between the variables and can model this relationship with a graph, with an equation and describe it precisely in words. ● In linear relationships, students can describe what the slope and y-intercept of the graph tell about the system.	● Students will be designing and carrying out experiments. ● Students will look at sample data/graphs and describe possible reasons for error in the results. ● Students will report sources of error and analyze their own results in lab reports. ● Students will analyze their own experimental results and report their analysis in a lab report. ● Students will conduct experiments and analyze the results. They will present their findings to the class and defend their conclusions. ● Students will ask questions in a Socratic format to understand/evaluate the models of other students. ● Students will write lab reports to explain and defend their model.

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	7.A Make a scientific claim. 7.B Support a claim with evidence from experimental data. 7.F Explain how potential sources of experimental error may affect results and/or conclusions ● Will analyze the results of their experiments to build a model that describes not only the specific situation in the lab, but a more general model of similar systems. This model should be given in graphical, mathematical and verbal formats. ● Clearly states under what circumstances their model is valid/useful. ● Clearly defends/explains the model they have constructed in class discussion and in written reports. They can also evaluate other student presentations. **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Identifies features of a well-designed experiment, such as dependent, independent variables. ● Knows that measurements must be repeated to minimize error. Therefore, when doing experiments, students will take multiple trials over a large range of values. ● Identifies possible sources of error, and can alter their procedure to minimize the effect of that error in their experiments. They can explain what effect the error could have on the results. ● Recognizes linear, proportional, quadratic and inverse relationships on graphs. ● Uses appropriate software to create and analyze graphs which are properly scaled and labeled. ● Will state and explain the general model, (i.e the conclusions the class came to as a result of the experiment.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	● Students will read descriptions of experimental procedures and determine if the experiment is valid and identify the independent/dependent variables. ● Students will practice making and analyzing graphs using Vernier Graphical Analysis software.

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: Kinematics (1-D and 2-D motion) CHA-1, CHA-2			
Grade: 11th & 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** CHA-1.A a. Determine the appropriate expressions for velocity and position as a function of time for an object accelerating uniformly in one dimension with given initial conditions. Calculate unknown variables of motion such as acceleration, velocity, or positions for an object undergoing uniformly accelerated motion in one dimension. c. Calculate values such as average velocity or minimum or maximum velocity for an object in uniform acceleration. CHA-1.C Describe the motion of an object in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. ● Explain what a reference frame is and why it is necessary to describe quantities such as position or velocity. Will define an appropriate reference frame when problem solving. Students can modify the frame from the standard to make solutions easier/more efficient. ● Will model more complex motion (object turns around, or undergoes different types of motion at different times) in the ways described below. ● Can use the basic kinematics equations to solve problems with more complex motion (described above.) ● Will sketch and use appropriate graphs when problem solving. ● Uses experimental data to determine the acceleration due to gravity. ● Will describe, qualitatively, the effect of air resistance/drag on a moving object. ● Will assess when it is appropriate to ignore the effects of air resistance CHA-2.A a. Calculate the components of a velocity, position, or acceleration vector in two dimensions. b. Calculate a net displacement of an object moving		● Students apply vector skills in problem solving. ● In class discussion, students will share how they defined a reference frame to solve a problem. Students will compare different choices to see which made the problem simpler. ● Solve problems using both graphs and equations, and then in class discussions evaluate which methods are easiest/most efficient. ● Students will use a video of a projectile to analyze the motion. ● Projectile target shoot. Students must hit the bulls-eye! ● Students will conduct experiments, observing different types of motion and use the results to derive the basic kinematic equations. ● Given two cars a set distance apart, students predict where the cars will collide. We will then test their predictions.

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	in two dimensions. c. Calculate a net change in velocity of an object moving in two dimensions. d. Calculate an average acceleration vector for an object moving in two dimensions. e. Calculate a velocity vector for an object moving relative to another object (or frame of reference) that moves with a uniform velocity. f. Describe the velocity vector for one object relative to a second object with respect to its frame of reference. CHA-2.B Derive an expression for the vector position, velocity, or acceleration of a particle, at some point in its trajectory, using a vector expression or using two simultaneous equations. CHA-2.C Calculate kinematic quantities of an object in projectile motion, such as displacement, velocity, speed, acceleration, and time, given initial conditions of various launch angles, including a horizontal launch at some point in its trajectory. CHA-2.D Describe the motion of an object in two-dimensional motion in terms of the consistency that exists between position and time, velocity and time, and acceleration and time. ● Will apply basic vector skills (listed below) when problem solving. Students know when it is appropriate to use the techniques, without reminders. ● Can add any two vectors together. ● Will solve problems involving projectiles launched at any angle from any height. (Can predict range, max height, launch velocity, etc.) ● Will derive the constant acceleration equations. ● Will correctly use the equations in more complex problem solving (an object has multiple accelerations, turns around or there is more than one moving object.) **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**	● Students will practice the mathematical skills needed to work with vectors.

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	• Knows the difference between vector and scalar quantities and can give examples of each. Students know how the directions of both one- and two-dimensional vectors are represented mathematically. • Knows the definitions of basic vector terms, such as magnitude, resultant and component. • Know what the variables in the following basic equations stand for. $(\vec{x} = \vec{x}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2 , \overrightarrow{v_x} = \vec{v}_{0x} + \overrightarrow{a_x}t ,\ v_x^2 = v_{0x}^2 + 2\vec{a}_x(\vec{x} - \vec{x}_0))$ • Knows under what conditions the equations are valid. • Uses a reference frame to describe the direction of vectors. • After observing motion or reading a description of simple motion (moving in only one direction or only one type of motion), students can o build an position vs time graph o build a velocity vs time graph o draw a diagram (for example, a motion map) o write an equation to model the motion. • Given a motion graph (x vs t, v vs t, a vs t) students can o Sketch the other two graphs o Describe the motion being modeled • Use the equations to solve simple problems (only a single equation is needed or only one object is moving.) • Will differentiate between average and instantaneous quantities. • Will describe what features of the graph (slope, y-intercept, area under the curve) tell us about the motion, if anything. • Will break a 2D vector into components, or given components can find the magnitude and direction. • Will add vectors that are parallel or perpendicular. • Understands that the horizontal and vertical components of projectile motion are independent. They can use this understanding to qualitatively compare the motion of different projectiles. • Solves simple problems involving projectiles (horizontal launch, or launched from ground to ground.) **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	• Students will practice describing the position of an object relative to various reference frames. • Students mark the position (at different times) of a toy car moving down the hallway. Then analyze the data to build a model of the motion. • Students do a similar analysis of an accelerating object. • Students are given a position vs time graph and then determine how they must move in front of a motion detector to produce that graph. They then sketch velocity and acceleration graphs that also model the situation. • Students will practice solving problems involving projectiles. • Students will practice using the equations in problem solving.

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: Newton's Laws INT-1, INT-3			
Grade: 11th & 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student will:** INT-1.A Describe an object (either in a state of equilibrium or acceleration) in different types of physical situations such as inclines, falling through air resistance, Atwood machines, or circular tracks). INT-1.B a. Explain Newton's first law in qualitative terms and apply the law to many different physical situations. b. Calculate a force of unknown magnitude acting on an object in equilibrium. INT-1.C a. Calculate the acceleration of an object moving in one dimension when a single constant force (or a net constant force) acts on the object during a known interval of time. b. Calculate the average force acting on an object moving in a plane with a velocity vector that is changing over a specified time interval. c. Describe the trajectory of a moving object that experiences a constant force in a direction perpendicular to its initial velocity vector. d. Derive an expression for the net force on an object in translational motion. e. Derive a complete Newton's second law statement (in the appropriate direction) for an object in various physical dynamic situations (e.g., mass on incline, mass in elevator, strings/pulleys, or Atwood machines). INT-1.D Calculate a value for an unknown force acting on an object accelerating in a dynamic situation (e.g., inclines, Atwood machines, falling with air resistance, pulley systems, mass in elevator, etc.). INT-1.E a. Describe the relationship between frictional force and the normal force for static friction and for kinetic friction. b. Explain when to use the static frictional relationship versus the kinetic frictional relationship in different		● Students will collect data on the stretch/compression of spring to derive Hooke's Law. ● Students will practice using the equations that model the magnitude of each force when problem solving. ● Students will practice problem solving in situations involving multiple interacting bodies. ● Students will collect data about the net force, mass and acceleration of a system in order to derive Newton's 2nd Law. ● Students will practice problem solving involving Newton's Laws.

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	physical situations (e.g., object sliding on surface or object not slipping on incline). INT-1.F Describe the direction of frictional forces (static or kinetic) acting on an object under various physical situations. INT-1.G a. Derive expressions that relate mass, forces, or angles of inclines for various slipping conditions with friction. b. Calculate the value for the static frictional force for an object in various dynamic situations (e.g., an object at rest on a truck bed, an object at rest on an incline, or an object pinned to a horizontal surface). ● Will derive Newton's 1st and 2nd law based on observations and data collected in the lab. ● Uses Newton's 1st and 2nd Law to predict the motion of objects in more complex problems or can use the motion to find the value of the forces needed to produce it in more complex situations (inclined planes, forces in both x & y directions) ● Uses the"fun" equation to calculate the force of friction, understanding when to use the inequality/equality. ● Understands Hooke's Law and can use this law to calculate tension, spring constant or distortion. INT-3.A a. Describe the forces of interaction between two objects (Newton's third law). b. Describe pairs of forces that occur in a physical system due to Newton's third law. c. Describe the forces that occur between two (or more) objects accelerating together (e.g., in contact or connected by light strings, springs, or cords). INT-3.B Derive expressions that relate the acceleration of multiple connected masses moving in a system (e.g., Atwood machines) connected by light strings with tensions (and pulleys). ● Students will apply Newton's 3rd Law to problem solving involving multiple objects. ● Will state Newton's 3rd Law and can use it to explain situations such as why a rocket rises or how we walk. ● Will give the Newton's 3rd law pair force for any given force.	

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	The student exhibits no major errors or omissions.		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Will identify when various types of forces (gravity, friction, normal, tension) occur and the direction they act. ● Understands that tension and normal forces occur as the result of distortions (stretches/compressions) of an object. ● Understands the concept of coefficient of friction and can differentiate between static and kinetic friction ● Understands the difference between mass and weight and can calculate one if given the other. ● Understands that a force is an interaction between two objects that can result in acceleration. Students understand that the net force affects the motion of an object and can use the net force to predict if the object accelerates. ● Will draw a force diagram to represent the individual forces that act on a system. Students can write summation statements to represent the net force acting on an object in the x and y directions. ● Use Newton's 1st and 2nd Law to predict the motion of an object in simple situations (motion in only x or y direction, only horizontal or vertical forces.) or can use the motion to find the value of unknown forces in simple situations. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Students will conduct a lab, measuring both mass and weight to derive the relationship between the two for objects on Earth. ● Students will collect data on the normal force and friction acting on a block to investigate coefficients of friction for both static and kinetic cases. ● Students will observe objects moving with and without friction in order to derive/understand Newton's 1st Law. ● Students will practice drawing force diagrams for a variety of situations. Students will practice writing summation statements of forces based on a force diagram. ● Students will practice using those summation statements in problem solving. ● Students will investigate Newton's 3rd by comparing the forces objects exert on each other in a variety of situations.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand: Work and Energy INT-4, CON-1, CON-2			
Topic: Work and Energy			
Grade: 11th & 12th			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** INT-4.A a. Calculate work done by a given force (constant or as a given function F(x)) on an object that undergoes a specified displacement. b. Describe the work done on an object as the result of the scalar product between force and displacement. c. Explain how the work done on an object by an applied force acting on an object can be negative or zero. INT-4.B Calculate a value for work done on an object from a force versus position graph. INT-4.C a. Calculate the change in kinetic energy due to the work done on an object or a system by a single force or multiple forces. b. Calculate the net work done on an object that undergoes a specified change in speed or change in kinetic energy. c. Calculate changes in an object's kinetic energy or changes in speed that result from the application of specified forces. ● Will calculate the work done by a constant force using the relation $W = F\,\Delta x \cos\theta.$ ● Will calculate the work done by a varying force using the area under a force vs. position graph. CON-1.D a. Derive the expression for the potential energy function of an ideal spring. CON-1.E Calculate the potential energy of a system consisting of an object in a uniform gravitational field.		● Students will collect data using springs to relate force, stretch and elastic energy. ● Students will use area under force vs. position graphs to derive the formulae. ● Students practice calculations of work with constant and non-constant forces. ● Students will practice solving problems involving the conservation of energy. ● Students will use conservation of energy in the lab to predict the distance a bungee jumper will fall when dropped from a specified height.

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	CON-2.A a. Describe physical situations in which mechanical energy of an object in a system is converted to other forms of energy in the system. b. Describe physical situations in which the total mechanical energy of an object in a system changes or remains constant. CON-2.B Describe kinetic energy, potential energy, and total energy in relation to time (or position) for a "conservative" mechanical system. CON-2.C a. Calculate unknown quantities (e.g., speed or positions of an object) that are in a conservative system of connected objects, such as the masses in an Atwood machine, masses connected with pulley/ string combinations, or the masses in a modified Atwood machine. b. Calculate unknown quantities, such as speed or positions of an object that is under the influence of an ideal spring. c. Calculate unknown quantities, such as speed or positions of an object that is moving under the influence of some other non constant one dimensional force. ● Uses lab data to derive the formula for various energy storage mechanisms. ● Uses the formulae ($E_k = \frac{1}{2}mv^2$, $E_g = mgh$, $E_{el} = \frac{1}{2}k(\Delta x)^2$, $E_{Diss} = F_f \Delta x$) to correctly calculate the amount of energy stored. ● Use the law of conservation of energy, and the concept of work to predict the behavior/characteristics of objects in an open or closed system. (For example, to find the velocity or height of an object at a specific point, to find how much a spring will be compressed or to find how much heat is generated.) **The student exhibits no major errors or omissions.**	
	2.5 No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Understands that motion is the indicator of kinetic energy in a system and that the amount of Ek is related to the mass and velocity of the system.	● Students will practice identifying where the energy is stored in various situations. ● Students will analyze examples of forces and motion to determine if work is done.

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	● Understands that elevation is the indicator of gravitational energy in a system and that the amount of Eg is related to the mass, height and gravitational field. ● Understands that distortion is the indicator of stored elastic energy and that the amount of Eel is related to stretch/compression and spring constant. ● Understand that heat and sound are indicators of dissipated energy and that energy is dissipated most often by friction/drag and collision. ● So, students can use the indicators listed above to identify energy storage and changes within a system. ● Will state the Law of Conservation of Energy. ● Distinguishes between open and closed systems and when work is/is not done. ● Uses diagrams (pie charts or bar graphs) to show how the storage of energy changes in a system and to show that energy is conserved. ● Understands that work is the transfer of energy into or out of a system by means of a force and can identify situations in which work is done. ● Will explain why work is only done if the system is displaced in a direction that is parallel to a component of the force. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**	● Students will describe the energy flow of the same situation with different systems to show that work is dependent on the choice of system. ● Students will practice modeling the energy flow with pie charts and bar graphs.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Applied Science ***Applied Science is the study of matter and the transformation it undergoes.***	
Grade level(s): 11-12	**Credits earned:** 0.5 credits per semester
Course Rationale	**Course Description**
This science course provides students with a foundation in the understanding of matter and its transformations.	*Applied Science is the study of matter and the transformations that it undergoes. Topics include atomic theory, the periodic table, chemical reactions, and nuclear chemistry. Emphasis is on problem solving and applying the scientific method.*
Transfer Goals/Big Ideas	
● **Asking Questions and Defining Problems** ● **Developing and using models** ● **Planning and carrying out investigations** ● **Analyzing and interpreting data** ● **Using mathematics and computational thinking** ● **Constructing explanations and designing solutions** ● **Engaging in an argument from evidence** ● **Obtaining, evaluating, and communication information**	
Priority Missouri Learning Standards/National Standards	
● **9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.]** ● **9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on**	

simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]

- **9-12.PS1.A.2 Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, or of oxygen and hydrogen.]**
- **9-12.PS1.A.3 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.]**
- **9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on conservation of matter and mass through balanced chemical equations, use of the mole concept and proportional relationships.]**
- **9-12.PS1.A.4 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strength of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite).**

<table>
<tr><th colspan="3"> 
Unit 1: Laboratory Safety
Proper Experimental Procedure</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.PS1.A.4</td><td colspan="2">BIG IDEA 4: SCIENCE PRACTICES
As a science, chemistry requires experimentation to collect viable data that can support or refute scientific claims. All experimentation must be done in a valid, safe way to preserve the integrity of the data as well as to protect the health of the scientist. Experimental data is the cornerstone to scientific theories and hypotheses as it provides evidence for scientific claims.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select safe, appropriate investigative methods in order to obtain evidence relevant to the explanation.
Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)</td><td>How do scientists approach solving problems?
How can an experiment be conducted in a safe, controlled environment?
Where are and how do you operate the laboratory safety equipment?
How do you properly use lab equipment?
What is/are the proper responses to a laboratory emergency?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
</table>

Students will… **Design and conduct a valid experiment.** **Manipulate laboratory equipment safely.** **Measure accurately in the metric system.**
Unit Duration:
1 week

Unit 2: Principles of Chemistry
Introduction to Matter

Standards	Transfer Goal(s) /Big Ideas	
● **9-12.PS1.A.4**	**BIG IDEA 3: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.**	
	Enduring Understandings	**Essential Questions**
	● **Properties of a substance can change with alterations to its atomic/molecular structure** ● **Substances can be changed on a macroscopic level that will not alter its chemical properties** ● **Substances have properties that can be used to describe and classify them** ● **While pure substances contain molecules or formula units of a single type, mixtures contain molecules or formula units of two or more types, whose relative proportions can vary**	1. **How are the properties of matter defined by its classification?** 2. **How does the atomic/molecular arrangement dictate the state of a substance?** 3. **How do energy changes affect the macroscopic and particle states of a substance?** 4. **What does a chemical formula tell us about a compound?**

Learning Targets
Students will… ● **Classify substances as elements, compounds or mixtures.** ● **Distinguish between different states of matter at the macro and particle levels.** ● **Distinguish between physical and chemical changes.** ● **Use chemical and physical properties to identify an unknown substance.** ● **Separate a mixture into its component substances.** ● **Interpret a phase change diagram.**
Unit Duration:
3 - 4 weeks

Unit 3: Atomic Structure

The Atom and The Parts That Are Contained Within

Standards	Transfer Goal(s) /Big Ideas	
● **9-12.PS1.A.4** ● **9-12.PS1.C.1**	**BIG IDEA 2: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.**	
	Enduring Understandings	**Essential Questions**
	● **Elements are made up of atoms that are composed of smaller particles.** ● **A Coulombic force exists between charged particles.** ● **Transmutations can occur by changing an atom's nucleus.** ● **There are multiple types of radioactive decay.** ● **The rate of decay for a nucleus is represented by its half-life.**	1. **What is the structure of an atom?** 2. **What gives an element its properties?** 3. **How can nuclei of the same element differ?** 4. **What happens when a nucleus changes?** 5. **What happens when an atom gains or loses electrons?** 6. **How is the Coulombic force between charged particles influenced by distance between the charged particles and the magnitude of charge?** 7. **How does an atom change if the composition of the nucleus is altered?** 8. **How are nuclear reactions balanced?** 9. **How is half-life calculated?**

Learning Targets
Students will… ● **Describe the atom as having a dense, positive nucleus surrounded by a cloud of negative electrons.** ● **Determine the number of protons, electrons and neutrons in a particular isotope.** ● **Know the charge and relative masses of each subatomic particle.** ● **Know that mass numbers must be whole numbers but atomic mass may be decimal.** ● **Know that atomic number determines the identity of the atom.** ● **Qualitatively use Coulomb's Law to describe the attractive/repulsive forces between charged particles.** ● **Be able to balance a nuclear decay reaction for alpha and beta decay.** ● **Be able to calculate the half-life of a chemical species.**
Unit Duration:
4 weeks

<table>
<tr><th colspan="3">Unit 4: Periodic Table
Understanding the Periodic Table and the Patterns Within</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● 9-12.PS1.A.1</td><td colspan="2">BIG IDEA 2: STRUCTURE AND PROPERTIES
Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● The organization of the periodic table is based on the properties of the elements
● Patterns in the periodic table can be found to describe the relative size of an atom or ion as well as the reactivity of an atom or ion</td><td>1. How does the structure of the periodic table allow us to predict the chemical and physical properties of an element?
2. How does electron arrangement determine bonding?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
● Be able to describe how the valence electron configuration determines how atoms interact and may bond.
● Be able to describe the chemical and physical properties of an element based on its position on the periodic table.
● Be able to draw a Lewis dot structure for elements and ions.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">3-4 Weeks</td></tr>
</table>

Unit 5: Ionic Bonds
Ionic Bonding and Replacement Reactions

Standards	Transfer Goal(s) /Big Ideas	
● 9-12.PS1.A.3 ● 9-12.PS1.B.3	**BIG IDEA 2: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.** **BIG IDEA 3: TRANSFORMATIONS** **At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.**	
	Enduring Understandings	**Essential Questions**
	● **The type of bonding affects the properties of a compound.** ● **The type of bond determines its nomenclature.** ● **Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.**	1. **How does electron arrangement determine bonding?** 2. **How are compounds named?** 3. **How is the formula for an ionic compound determined?** 4. **How does the law of conservation of mass relate to balancing equations?**

Learning Targets
Students will… **Students will be able to describe how the valence electron configuration determines how atoms interact and may bond.** **Students will be able to compare and contrast ionic, covalent and metallic bonding.** **Students will be able to write the formula and name ionic compounds.** **Students will be able to write a chemical equation as a chemist's shorthand method of describing a chemical change.**
Unit Duration:
3-4 Weeks

Unit 6: Covalent Bonds
Covalent Bonding, Molecular Structures and Redox Reactions

Standards	Transfer Goal(s) /Big Ideas
● 9-12.PS1.A.3 ● 9-12.PS1.B.3	**BIG IDEA 2: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.** **BIG IDEA 3: TRANSFORMATIONS** **At its heart, chemistry is about the rearrangement of matter. Understanding the details of these transformations requires reasoning at many levels as one must quantify what is occurring both macroscopically and at the atomic level during the process. This reasoning can be as simple as monitoring amounts of products made or as complex as visualizing the intermolecular forces among the species in a mixture. The rate of a transformation is also of interest, as particles must move and collide to initiate reaction events.**

Enduring Understandings	Essential Questions
● **The type of bond determines its nomenclature.** ● **Molecular formulas show the number of each type of atom in a molecule** ● **Molecules have particular shapes depending on number of atoms and electron domains** ● **Balanced chemical equations are used to derive relationships between reactants and products in a chemical change.**	1. **How are compounds named?** 2. **How is the structure for a covalent compound determined?** 3. **How do electron domains affect the molecule's shape?** 4. **How does the law of conservation of mass relate to balancing equations?** 5. **How do scientists determine the molecular formula of a compound?**

Learning Targets
Students will… ● **Be able to name a covalent compound correctly.** ● **Be able to draw the Lewis structure for a covalent compound.** ● **Be able to recognize linear, bent, pyramidal and tetrahedral molecular shapes.** ● **Be able to determine the molecular formula of a compound.**
Unit Duration:
2-3 Weeks

<table>
<tr><td colspan="3">Unit 7: The Mole
Mole Conversions</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>1. The mole is used to represent a large collection of particles.
2. Quantities of a substance can be expressed in terms of moles, mass, volume, and number of particles.
3. Mass and atoms must be conserved in a chemical reaction.</td><td>1. How do scientists represent very large or small chemical quantities?
2. How do scientists calculate the mass or volume of a substance?
3. How does the law of conservation of mass relate to balancing equations?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">Students will…
4. Be able to use atomic mass to calculate the molar mass of a substance.
5. Be able to calculate the number of moles, the amount of mass or volume, and the number of particles in a substance.</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">3-4 Weeks</td></tr>
</table>

Unit 8: Stoichiometry
Stoichiometry

Standards	Transfer Goal(s) /Big Ideas	
• **9-12.PS1.B.3**	**BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY** **Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.**	
	Enduring Understandings	**Essential Questions**
	6. A balanced chemical equation is necessary to relate quantities of reactants and products. **7. Reactants and products in a chemical reaction are quantitatively related by the mole.** **8. The amount of product recovered is determined by the limiting reactant.** **9. Numerous factors influence the percent yield of a chemical reaction.**	**1. How are quantities of reactants and products related?** **2. What factor(s) influence the actual yield?** **3. How is the theoretical yield of a chemical reaction calculated?**

Learning Targets

Students will…

10. Be able to use a balanced chemical equation to describe the mole ratio between reactants and products.
11. Be able to calculate the theoretical yield of a product or calculate the amount of reactant needed to produce a given theoretical yield for a chemical reaction.
12. Be able to calculate the percent yield of a chemical reaction.
13. Be able to determine the limiting reactant in a chemical reaction.

Unit Duration:

3-4 weeks

<table>
<tr><th colspan="3">Unit 9: Gas Laws
KMT and Gas Laws</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">● 9-12.PS1.B.3</td><td colspan="2">BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY
Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Kinetic molecular theory can be used to explain the difference in properties of solids, liquids and gases.
● Gas behavior can be quantitatively described using pressure, temperature, volume and mole relationships.</td><td>1. How is the physical state of matter related to the particle behavior of a substance?
2. What are the major tenets of kinetic molecular theory?
3. Under what conditions do real gases behave like ideal gases?
4. How does the behavior of gas particles change with alterations to pressure, volume, temperature and mole amounts?</td></tr>
<tr><th colspan="3">Learning Targets</th></tr>
<tr><td colspan="3">Students will…
● Use the kinetic molecular theory to explain the difference in properties and structure of solids, liquids and gases.
● Use pressure, temperature, volume and number of moles to quantitatively describe a gas.
● Be able to relate the molar quantities of gases with stoichiometry .
● Be able to contrast the properties of real and ideal gases.</td></tr>
</table>

Unit Duration:
3-4 Weeks



Unit 10: Solution Chemistry
Solutions, Acids and Bases

Standards	Transfer Goal(s) /Big Ideas	
-9-12.PS1.B.3	**BIG IDEA 1: SCALE, PROPORTION, AND QUANTITY** **Quantities in chemistry are expressed at both the macroscopic and atomic scale. Explanations, predictions, and other forms of argumentation in chemistry require understanding the meaning of these quantities, and the relationship between quantities at the same scale and across scales.** **BIG IDEA 2: STRUCTURE AND PROPERTIES** **Properties of substances observable at the macroscopic scale emerge from the structures of atoms and molecules and the interactions between them. Chemical reasoning moves in both directions across these scales. Properties are predicted from known aspects of the structures and interactions at the atomic scale. Observed properties are used to infer aspects of the structures and interactions.**	
	Enduring Understandings	**Essential Questions**
	1. **Solutions can be described in both qualitative and quantitative terms.** 2. **Solutions can be classified as acidic or basic based upon the concentration of hydrogen and hydroxide ions present.**	1. **How are solutions differentiated from other types of mixtures?** 2. **What properties define an acid or a base?** 3. **How are indicators used to identify a solution as an acid or base?**

Learning Targets
Students will… ● **Be able to qualitatively and quantitatively describe a solution.** ● **Identify a solution as acidic or basic based upon the pH of the solution.** ● **Calculate the pH of a solution given the concentration of the hydrogen ions in solution.**
Unit Duration:
2-3 Weeks

Strand 1: 9-12.PS1.A.1			
Topic: Periodic Table and Element Properties			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the charges of the ions formed by an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for monatomic ions. ● Will be able to determine the composition and electron configuration of an atom. ● Is able to explain the underlying causes of the regular and repeating patterns of chemical and physical properties within the periodic table **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	

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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to identify the number of subatomic particles in an atom given its atomic and mass number. ● Be able to identify the subatomic particles of an atom and their location. ● Is able to identify the atomic structure of an element based on its position on the periodic table. ● Is able to draw Lewis Dot structures for single atoms. ● Is able to recognize the regular and repeating pattern of chemical and physical properties within the periodic table. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 2: 9-12.PS1.A.2			
Topic: Bonding and Chemical Reactions			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Recognizes how valence electrons are used in bonding. ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to predict based on reactivity of the reactants and states of the products if a reaction will occur in the forward direction. ● Is able to write a net ionic equation. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to predict the products of chemical reactions. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 3: 9-12.PS1.A.3			
Topic: Bonding and Intermolecular Forces			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to predict the properties of a compound based upon its bond type. ● Is able to write formulas for ionic and covalent compounds including application of ionic polyatomic nomenclature and multiple charge ion nomenclature. ● Is able to draw molecular structures that may include single or multiple bonds using Lewis Dot Structures. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to classify a substance as ionic or covalent. ● Is able to write simple formulas for binary compounds. ● Is able to draw molecular structures that include single Lewis Dot Structures. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	

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Score 0.0	**Even with help, no understanding or skill demonstrated.**	

Strand 4: 9-12.PS1.B.3			
Topic: Chemical Quantities			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** ● **Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Is able to convert between moles and grams, liters and particles. ● Is able to write and balance chemical equations ● Is able to use a balanced chemical equation to derive quantitative relationships involved in a chemical change. ● Is able to calculate theoretical yield, actual yield and percent yield given the appropriate information. ● Be able to relate the molar quantities of gases with stoichiometry **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Is able to calculate the molar mass of a compound. ● Is able to understand the concept of conservation of mass as related to the balancing of chemical equations. ● Understands that coefficients in a balanced chemical equation show a molar relationship between products and reactants.		

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	● Is able to differentiate between theoretical yield, actual yield and percent yield. ● Use pressure, temperature, volume and number of moles to quantitatively describe a gas. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 5: 9-12.PS1.A.4			
Topic: Experimental Design			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** ● **Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles.**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Recognize the difference between accuracy and precision. ● Is able to recognize and explain sources of error in a scientific experiment. ● Is able to plan and safely conduct a valid, scientific experiment. ● Demonstrates sound knowledge of lab procedures. ● Uses safe laboratory practices independently. **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Performs basic processes, such as: measure length, mass, volume and temperature ● Recognizes or recalls specific terminology such as: base units of		

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	measurement, metric prefixes, measurement tools, significant figures, percent error. ● Works to follow each step before moving on to the next step ● Work is organized using appropriate units and labels. ● Is able to communicate experimental results in graphical and tabular form. ● Is able to correctly identify and use lab equipment. ● Follows lab safety guidelines. **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 5: 9-12.PS1.A.4			
Topic: Nuclear Chemistry			
Grade: 11			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities** ● **9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Will be able to balance nuclear equations for alpha and beta decay. ● Will understand half-life concepts and be able to solve half-life problems. ● WIl be able to compare and contrast the difference between fission and fusion **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology such as: nuclear decay, alpha decay, beta decay, gamma radiation, half-life, fission, fusion		

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	● Will be able to explain the benefits and risks of radioactivity. ● WIl be able to define fission and fusion **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Forensic Science The use of science to solve crime and enforce laws and regulations	
Grade level(s):11-12	**Credits earned:** 0.5 credits
Course Rationale	**Course Description**
The class is designed around authentic performance assessments with students working in teams to solve crimes using scientific knowledge and reasoning. It involves all areas of science including biology, anatomy, chemistry, physics, and earth science with an emphasis in complex reasoning and critical thinking.	This course is an overview of forensic investigation techniques and applies science to the law. It utilizes concepts in biology, chemistry and physics.
Transfer Goals/Big Ideas	
• **Asking Questions and Defining Problems** • **Developing and using models** • **Planning and carrying out investigations** • **Analyzing and interpreting data** • **Using mathematics and computational thinking** • **Constructing explanations and designing solutions** • **Engaging in an argument from evidence** • **Obtaining, evaluating, and communication information**	

Priority Missouri Learning Standards/National Standards
9-12.LS4.A.1 **Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** **evidence.** **(Clarification statement: Emphasis is on a conceptual** **understanding of the role each line of evidence has** **relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological** **development. Communicate could mean a written report, oral discussion, etc.)**

Course Name:

<table>
<tr><th colspan="3">Unit 1: Introduction to Forensic Science
Focus on History, Legal aspects, and areas of Study</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS4.A.1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
evidence.

(Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)</td><td colspan="2">● Obtaining, evaluating, and communication information</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations
● Scientific inquiry includes evaluation of explanations (laws/principles, theories/models) in light of evidence (data) and scientific principles (understandings)
● The nature of science relies upon communication of results and justification of explanations
● Forensic Science is an applied science which pulls from other scientific fields
● Forensic Science has a lengthy history that continues to evolve with technological advances</td><td>1. What are the different ways that science is used to help investigate and try legal matters?
2. How has forensic science changed criminal investigation?
3. How does the U.S. Bill of Rights protect people from certain types of investigation?
4. What areas of science could be used for Forensic study?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● ***Be able to explain how different sciences are used to help solve crimes*** ● ***Students will effectively classify evidence*** ● ***Students will be exposed to the various career possibilities in forensic science***
Unit Duration:
3-4 weeks

Course Name:

<table>
<tr><th colspan="3">Unit 2: Evidence/ Crime Scene
Evidence Collection and Processing a crime scene</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS4.A.1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
evidence.

(Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)</td><td colspan="2">● Planning and carrying out investigations
● Analyzing and interpreting data</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● The primary goal of Forensics is to recreate the crime scene
● Collecting and packaging evidence according to protocol is a critical process to solving crimes
● Searching and collecting evidence must be systematic in nature.
● Evidence can be classified based on its characteristics or type
● During decomposition certain bodily process occur that can be used to deduce time and cause of death
● Certain evidences have a higher probative value in that they can be individualized</td><td>1. What is the difference between physical and testimonial evidence? What are some problems with relying on eyewitness testimony only?
2. What is the difference between class and individual evidence?
3. How can class evidence be useful in solving a crime?
4. What is a chain of custody and what is its importance?
5. How is certain evidence collected?
6. What are the steps for the first officer on the scene?
7. What are the mortises and how can they aid in the investigation?
8. What is the Locard Exchange principle?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● define physical evidence and testimony ● list the responsibilities of the first officer on the scene (APAPT) ● thoroughly process a crime scene including taking notes, sketching the scene, and collecting evidence ● start a chain of custody and understand the importance in regards to collection of evidence ● search a crime scene using one of the four methods. ● define and contrast individual and class evidence ● properly collect evidence depending on the type of evidence ● understand the importance of securing a crime scene ● realize that individual evidence is preferred but that class evidence may be probative ● accept that eyewitness testimony can have unintentional errors present in the evidence ● identify problems associated with the CSI effect
Unit Duration: 3-4 weeks

Course Name:

<table>
<tr><td colspan="3">Unit 3: Fingerprints
Principles of Fingerprints</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="2">9-12.LS4.A.1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
evidence.

(Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)</td><td colspan="2"></td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● That fingerprints can be classified into three different patterns; arch, loops and whorls
● Fingerprints remain unchanged throughout an individual’s lifetime.
● Fingerprints have ridge characteristics called minutiae that make a fingerprint unique
● Fingerprints often require a treatment to make them visible. The treatment used is dependent on the surface.
● Fingerprints are individually unique, and thus have high probative value</td><td>1. How can fingerprints be used to solve crimes?
2. While there are only three fingerprints, what identifiable features allow us to make a positive match from a crime scene?
3. What gives a fingerprint its high probative value?
4. What technique should be used to lift prints from various surfaces?</td></tr>
</table>

Course Name:

Learning Targets
● ***Students can identify the different fingerprint patterns and locate deltas on the pattern.*** ● ***students can use various methods to develop prints*** ● ***students can compare two like fingerprints and match minutiae points*** ● ***students can create a clear, complete inked print*** ● ***Students can determine their primary ID number***
Unit Duration: 3-4 weeks

Course Name:

<table>
<tr><th colspan="3">Unit 4: Blood
Blood Spatter and Angle of Impact</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">9-12.LS4.A.1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
evidence.

(Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)</td><td colspan="2">● Analyzing and interpreting data
● Using mathematics and computational thinking</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>● Blood is made up of antibodies and antigens that allow us to classify blood type.
● Blood evidence is circumstantial evidence.
● Shape of blood droplets can be dependent on height, surface and angle of impact
● Using trigonometry, a point of origin can be determined.
● The physics of blood spatter is often a more accurate method of determining what happened at a crime scene than testimony.</td><td>1. How can blood spatter be used to recreate a crime scene?
2. How is the shape of blood spatter affected by angle of impact?
3. Does surface texture influence blood droplet behavior?
4. What category of evidence does blood spatter fall under?
5. How can blood evidence be analyzed for characteristics such as gender, relative age, blood type, etc…
6. How can the origin of the blood be determined?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● Be able to summarize activity at a crime scene based on types and placement of blood stains ● Can predict the relationship between distance fallen and size of drop ● Can calculate angle of impact ● Recognize how blood droplet shape is altered by various surface textures. ● Uses various methods to identify blood ● Locate the point of convergence.
Unit Duration: 3-4 weeks

Course Name:

Unit 5: Hair and Fiber
Morphology of Hair

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS4.A.1

Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
evidence.

(Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean a written report, oral discussion, etc.)</td><td colspan="2">● Analyzing and interpreting data</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Animal and human hair have similarities in their morphology but have variations in that structure that allow for investigators to distinguish them as human hair.
● Hair progresses through three different stages that change root shape which changes how much DNA can be extracted.
● Hair is generally considered class evidence unless it contains follicular tissue.
● Fibers have properties that can be determined using chemical testing</td><td>1. What is the morphology of the hair?
2. How can you identify whether a hair is animal or human
3. What is the difference between natural and man-made fibers?
4. When will DNA be attached to hair?
5. What are the different phases of hair growth?
6. What is the value of hair and fiber analysis to an investigation?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● Use a compound microscope to identify hair morphology and compare various samples of hair. ● Describe the structure of hair ● tell the difference between human and animal hair ● distinguish and identify fibers based on properties(chemical and heat test) ● explain the proper collection of hair and fiber
Unit Duration: 3-4 weeks

Strand 1: 9-12.LS4.A.1			
Topic: Intro to Forensic Science			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Student can understand and explain why scientific evidence is preferred to eyewitness testimony. ● can differentiate between types of evidence ● Predict whether evidence would be admissible **The student exhibits no major errors or omissions.**		● http://goo.gl/rxS4R4 ● http://goo.gl/OBLdSG ● forensic specialist presentations ● case analysis
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● recognizes or recalls specific terminology such as: ○ Locard's Principle, forensic science, physical/indirect evidence, ○ Direct/Testimonial evidence, Means, Motive, Opportunity, ○ Manner/Cause/Mechanism of death, due process ○ performs basic processes, such as: ○ Identifies the area of forensic study ○ Identify pertinent parts of the Bill of Rights **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		-Identify evidence as direct, indirect, class, and individual -Identify scenarios as legal or illegal under the 4th amendment
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 2: 9-12.LS4.A.1			
Topic: Evidence and Crime Scene Processing			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● will isolate, record and search for evidence in a mock crime scene ● create crime scene sketch containing relevant items ● take appropriate photographs of a crime scene **The student exhibits no major errors or omissions.**		● Process a mock crime scene- sketch,take ● notes and collect evidence ● evidence classification lab
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● **recognizes or recalls specific terminology such as:** ○ **chain of custody, warrants, rigor mortis, algor mortis, livor mortis,accumulated degree hour** ● **performs basic processes, such as:** ○ **determining time of death** ○ **properly package evidence** ○ **determine appropriate search patterns for a given scene** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● state how to collect evidence ● appropriately ● given temperature of body, determine ● time of death
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Strand 3: 9-12.LS4.A.1			
Topic: Fingerprints			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● students can use various methods to develop prints ● students can compare two like fingerprints and match minutiae points ● students can create a clear, complete inked print **The student exhibits no major errors or omissions.**		● Lifting prints in the lab ● matching minutiae points between two prints ● determining primary ID number
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● recognizes or recalls specific terminology such as: ○ fingerprints, loops, whorls, and arches, minutiae points, ○ latent/plastic/ visible prints ● performs basic processes, such as: ○ differentiate between fingerprint patterns ○ determine if a print is latent, plastic, or visible **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● given a fingerprint, identify whether the print is an arch, loop, or whorl
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	●

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Strand 4: 9-12.LS4.A.1			
Topic: Blood Spatter			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can predict the relationship between distance fallen and size of drop ● Can calculate angle of impact ● Uses various methods to identify blood ● Describe how DNA is fragmented and separated to match samples ● Differentiate between PCR and RFLP DNA analysis **The student exhibits no major errors or omissions.**		● Blood Labs: drop height, A.O.I., surface type ● summarize sequence of events at mock crime scene based on blood spatter ●
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● recognizes or recalls specific terminology such as: ○ serology, presumptive tests, passive patterns, impact patterns, void, projected stains, spines, satellites, DNA, electrophoresis ● performs basic processes, such as: ○ Identify blood as human or other ○ Find area of convergence of blood stains ○ Recognize basic DNA structure **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● determine area of convergence for a blood spatter sample ● identify general types of bloodstain patterns at a crime scene ● identify blood types

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	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

Strand 5: 9-12.LS4.A.1			
Topic: Hair and Fibers			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Be able to identify whether a hair belongs to an animal or human based on the morphology characteristics ● Identify what stage of growth, a sample of hair is in ● identify whether a fiber is natural or man-made based on properties **The student exhibits no major errors or omissions.**		● Hair structure lab ● Flame test for fibers ● Chemical test for fibers
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● recognizes or recalls specific terminology such as: ○ cuticle, cortex, medulla follicle, root anagen,catagen, telogen ● performs basic processes, such as: ○ identify characteristics of hair in a picture ○ can identify types of fibers as synthetic or natural **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Identify the morphology or key characteristics from hair ● distinguish between different basic fiber type samples through observations
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	

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Environmental Science ***A study of the interactions between humans and the Earth's natural systems.***	
Grade level(s): 11-12	**Credits earned: 0.5 credits**
Course Rationale	**Course Description**
This course provides a way in which students can become aware of the interactions of people and their environment. The curriculum focuses on concepts that are real-life issues. It promotes awareness and understanding of practical everyday problems that affect their lives. This understanding develops an appreciation of the environment.	Environmental Science is a curriculum that is designed to introduce students to major ecological concepts and the environmental problems that affect the world in which we live.
Transfer Goals/Big Ideas	
• **Asking Questions and Defining Problems** • **Developing and using models** • **Planning and carrying out investigations** • **Analyzing and interpreting data** • **Using mathematics and computational thinking** • **Constructing explanations and designing solutions** • **Engaging in an argument from evidence** • **Obtaining, evaluating, and communication information**	

Priority Missouri Learning Standards/National Standards
9-12.LS2.A **Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.** **9-12.LS4.C.2** **Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]** **9-12.ESS3.C.2** **Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences. [Clarification Statement: Examples of human activities could include forest fires, acid rain, flooding, urban development, pollution, deforestation, and introduction of an invasive species.]** **9-12.ESS3.D.2** **Predict how human activity affects the relationships between Earth systems in both positive and negative ways. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.]**

<table>
<tr><th colspan="3">Unit 1: Forestry</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS4.C.2</td><td colspan="2">● Analyzing and interpreting data
● Constructing explanations and designing solutions</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● Life processes can be disrupted by disease (intrinsic failures of the organ systems or by infection due to other organisms).
● The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.
● That there is an importance in the diversity of a forest and trees in an urban setting.
● Trees play an essential role in an ecosystem, providing habitat stability, photosynthetic processes, and influence the cycling of materials in the environment.</td><td>1. Why should we study forestry? Why are trees important? What ecological and economic value do trees have?
2. What are the different species of Missouri trees? How is this diversity determined? How has tree diversity changed over time for a particular area (Missouri)?
3. Are there specific characteristics that can help identify trees (leaves, seed, flower)?
4. Why are some trees better to plant in certain locations than others (landscaping)?
5. How can trees help save energy?
6. How can we evaluate the health of a tree? How can tree rings serve as a record of climate and weather phenomena?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● ***Be able to identify a tree species using a dichotomous key*** ● ***Evaluate the health of a tree using several factors to assess the crown, trunk and foliage.*** ● **design a landscape using characteristics of the tree to optimize energy considerations.**
Unit Duration:
3-4 weeks

Course Name:

<table>
<tr><th colspan="3">Unit 2: Aquatics</th></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="3">9-12.ESS3.C.2</td><td colspan="2">● Analyzing and interpreting data
● Engaging in an argument from evidence</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● All organisms, including humans, and their activities cause changes in their environment that affect the ecosystem
● Fresh water is limited and must be protected and conserved to ensure availability to humans.
● Flood plains have an important ecological function in protecting waterways.
● Earth’s materials are limited natural resources affected by human activity</td><td>1. How can we use fresh water more sustainably?
2. What are some ways that we can reduce pollution?
3. How can we reduce the threat of flooding?
4. How can we protect our watershed?
5. What do invertebrates say about the quality of a stream or pond?
6. How can we determine if waterways are healthy?</td></tr>
<tr><td colspan="3">Learning Targets</td></tr>
<tr><td colspan="3">● Students will…
● Be able to understand the importance of protecting and conserving freshwater
● Understand that their everyday activities have an effect on water quality
● Use water quality testing kits to determine the health of neighborhood streams
● Use macroinvertebrates and microorganisms to determine long term health of a stream</td></tr>
<tr><td colspan="3">Unit Duration:</td></tr>
<tr><td colspan="3">3-4 weeks</td></tr>
</table>

<table>
<tr><th colspan="3">Unit 3: Wildlife</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.LS2.A</td><td colspan="2">● Obtaining, evaluating, and communication information
● Developing and using models</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>● Organisms progress through their own unique life cycle
● Biological classifications are based on relation of organisms to each other
● Every species of organism has inheritable variation
● Balanced ecosystems rely on interaction between all organisms and the resources available in the ecosystem
● Living organisms will reach a carrying capacity due to the limited resources that are available
● All activities (including human) cause change in ecosystems
● Species diversity is influenced by external factors as well</td><td>1. How are various species connected?
2. What effects do each organism have on the overall food web or ecosystem they reside in?
3. How are survival of the fittest and predation beneficial to the prey species as well as the ecosystem?
4. How has the change (evolution) of a species been affected or selected by the surrounding environment?
5. What factors determine the type of biome an area is considered to be?
6. How does biomass affect population density?
7. What types of succession are there and when/where can they be found?
8. How is matter cycled through an ecosystem?</td></tr>
</table>

Course Name:

Learning Targets
Students will… ● Create a balanced food web, comparing a food web to a food chain ● predict the overall effect on an ecosystem when one component is removed ● Cite examples of common issues faced by organisms (bio. magnification, overcompetition, bottlenecking) where heredity plays a crucial role in survival of the fittest. ● identify mammals based on bone characteristics ● understand that organisms are interdependent ● Understand ecosystems have a delicate balance that must be maintained ● Understand that both species density and diversity are limited by available abiotic factors
Unit Duration:
3-4 weeks

Course Name:

<table>
<tr><th colspan="3">Unit 4: Current Issues</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">9-12.ESS3.D.2</td><td colspan="2">● Constructing explanations and designing solutions
● Engaging in an argument from evidence
● Analyzing and interpreting data</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>● All organisms, including human activity cause changes in the environment which affects the ecosystem
● Earth’s materials are limited natural resources affected by human activity
● Climate is a description of the average weather conditions in a given area due to the transfer of energy and matter through the system (Earth)
● Advances in technology often result in improved data collection an increased scientific understanding
● Scientific theories are developed based on current information and must be rigorously tested for validity
● The progress of science and technology greatly affects the current social, political,</td><td>1. Are students aware of their impact on the environment through daily activities?
2. How are resources made available through refinery and processing?
3. What are the differences between reusable and recyclable materials?
4. How have theories such as global warming changed or been enhanced with new information?
5. Can students calculate their carbon footprint as well as offer solutions to reducing it?</td></tr>
</table>

	economic, ethical, and environmental ideals of a society	

Learning Targets

Students will…

- Calculate a carbon footprint
- design a “green” home and produce a scalar model
- Predict the annual amount of waste produced per person, as well as offer valid option to minimize waste
- Calculate population growth in humans and discuss potential ramifications of exponential growth of humans
- Describe how Earth’s climate has been altered in recent history (mechanisms)
- Research both sides to controversial theories and make an informed decision regarding your stance based on evidential findings
- Develop and /or ***implement*** green techniques at home
- Be a conscientious consumer
- Filter materials found online and be conscientious of pseudoscience and bias perspectives

Unit Duration:

3-4 weeks

Course Name:

Course Name:

Strand 1: 9-12.LS4.C.2			
Topic: Forestry			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can identify Missouri's common trees ● can evaluate the health of a tree ● can identify ways that trees can help save energy **The student exhibits no major errors or omissions.**		● Given a leaf/seed/characteristic can identify MO trees ● create a landscape design featuring plants that can provide benefits to the area.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● **recognizes or recalls specific terminology, such as:** ○ **simple leaf and compound leaf** ○ **identify factors to look for when evaluating the health of a tree** ○ **performs basic processes, such as: using a tree guide to identify trees** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Forest Keeper curriculum- determine the health of a tree using the diameter at breast height, crown, trunk and foliage
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 2: 9-12.ESS3.C.2			
Topic: Aquatics			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● Can determine health of a stream using visual, chemical and macroinvertebrate surveys ● Students can explain why development on a floodplain can have detrimental effects on land downstream ● Students understand that unintentional actions can have an effect on water quality ● Students can explain factors that can increase the quality of the water **The student exhibits no major errors or omissions.**		● Visit a neighborhood creek to determine quality of the creek using visual, chemical and macroinvertebrate surveys
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● **recognizes or recalls specific terminology, such as:** ○ **Dissolved oxygen** ○ **point source/nonpoint source pollution** ○ **macroinvertebrates** ○ **riparian corridor, Floodplain, watershed** ● **performs basic processes, such as:** ○ **given data from a stream can determine if a stream is healthy** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Complete watershed activities that emphasize the effect of humans on our waterways ● Look at examples of macroinvertebrates in the classroom and using a dichotomous key ● identify the organisms Identify stream characteristics (i.e. riparian corridor, riffles, pools, flood plain)
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 3: 9-12.LS2.A			
Topic: Wildlife			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Understands the necessary components and balance vital to a food web Predicts future population density based on existing conditions in an environment** **The student exhibits no major errors or omissions.**		● Prepares a graph from existing data ● Can use biomass (limiting factor) to construct a viable food web ● predict population trends based on external and internal factors for a species
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● **Recognizes or recalls specific terminology, such as:** ○ **niche** ○ **decomposer,** ○ **tertiary predator,** ○ **commensalism** ● **Performs basic processes, such as:** ○ **designs a food web,** ○ **graphs** ○ **population change** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		● Be able to create basic food webs ● Create a fictional animal with adaptations that will help the animal survive under certain conditions.
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Strand 4: 9-12.ESS3.D.2			
Topic: Current Issues			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● **Can effectively argue "both sides" of current theories / ideas regarding climate shift using supportive data** ● **Provides legitimate and well thought out plans to address climate concerns and human activity** ● **Is capable of calculating one's carbon footprint** ● **Actively participates in green activities such as recycling** **The student exhibits no major errors or omissions.**		● Determine your carbon footprint and designate specific ways to reduce it ● construct a green home model that incorporates green energy ● design waste management systems that focus on the reuse and recycling of materials ● Calculate the carrying capacity for the human species acknowledging concerns with exponential growth patterns ● Take part in a "mock environmental science" trial ● Develop and /or ***implement*** green techniques at home ● Be a conscientious consumer ● Filter materials found online and be conscientious of pseudoscience and bias perspectives

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	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** ● Recognizes or recalls specific terminology, such as: ○ oceanic acidification, ○ carbon footprint, ○ alternative energies ● Performs basic processes, such as: ○ interprets graphs and charts relative to human activity / population growth ○ identifies cause and effect for environmental / economic issues **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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[PLTW Principles of Biomedical Science] ***Course Overview***	
Grade level(s): 9-12	**Credits earned:** 0.5 credits of weighted high school science credit per semester with the potential to earn college credit through Missouri S&T if certain criteria are met.
Course Rationale	**Course Description**
[Why it is important] Thoughts maybe overarching Essential Questions? *Develop the conceptual and instructional understanding you'll need to guide students as they take on the role of forensic investigators, medical professionals, epidemiologists, and entrepreneurs in order to build their biomedical science knowledge and skills.* *Analyze the evidence found at a crime scene and help the medical examiner uncover clues left on a body to solve a mystery. Question, diagnose, and propose treatment and care for patients in a family medical practice. Track down the source of a mysterious outbreak at a local hospital. Access and stabilize a patient during an emergency and prepare for medical surge and mobile medical care. Collaborate with professionals in other fields to innovate and design solutions to local and global medical problems. Whether seeking a career in medicine or healthcare or simply looking to for the challenge of real-world problems, students in Principles of Biomedical Science will practice how to think creatively and critically to innovate in science and will gain practical experience with experimental design and the design process.*	*[Summary of what students will learn]* *Principles of Biomedical Science (PBS) is a full-year high school course in the PLTW Biomedical Science Program. This course serves to provide foundational knowledge and skills in fields such as biology, anatomy & physiology, genetics, microbiology, and epidemiology as well as engage students in how this content can be applied to real world situations, cases, and problems. Through both individual and collaborative team activities, projects, and problems, students will tackle real-world challenges faced by biomedical professionals in the field. They will work with the same tools and equipment used in hospitals and labs as they engage in relevant hands-on work. Students will develop skill in technical documentation to represent and communicate experimental findings and solutions to problems. In addition, students will explore how connections to other disciplines such as computer science and engineering shape the future of medicine and practice collaboration techniques that will help them connect with professionals across any field. The course requires a rigorous pace, and it is likely to contain more material than a skilled teacher new to the course will be able to complete in the first iteration. Building enthusiasm for and a real understanding of the*

	role, impact, and practice of biomedical scientists is a primary goal of the course.

Transfer Goals/Big Ideas

What are transfer Goals/ Big Ideas?

- **Tips for Teaching Transfer Goals**
- **Transfer Goal Article**
- **Understanding By Design Guide Advanced Concepts in Creating and Reviewing Units**
- **Transfer Goal Examples**
- **Big Ideas**
- Asking Questions and Defining Problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in an argument from evidence
- Obtaining, evaluating, and communication information

Priority Missouri Learning Standards/National Standards

[5-10 skills that every student must master]

Here, please write out the priority standards as they appear, verbatim, in the MODESE standards document.

Missouri Learning Standards

<table>
<tr><th colspan="3">Unit [1]: [Medical Investigation]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard)

Missouri Learning Standards</td><td colspan="2">Copy goals from the course overview page that fit this unit. (This will be more abstract than the Enduring Understandings)
In Unit 1 students engage in forensic science and medical examination investigations in order to: a.) explore biological and forensic science careers; b.) gain experience in experimental design and data analysis; c.) learn about biomolecules and their role in determining identity; d.) learn about human anatomy and physiology and causes of death; e.) practice synthesizing multiple forms of data to draw conclusions; and f.) work to develop professional communication skills.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>What are enduring understandings?
An experimental design process is a systematic approach to investigate and gain knowledge.
Biomedical science professionals approach complex problems systematically and logically by breaking them into manageable components. They work collaboratively and apply their knowledge and skills to draw well-reasoned conclusions and solutions.
Biomedical science solutions have global impacts in economic, environmental, and societal contexts.
Successful biomedical scientists typically exhibit specific personal and professional characteristics that lend themselves to the creative,</td><td>What are essential Questions?
What are different forms of evidence, how infallible are they, and how are they useful in resolving potential criminal cases?
How can varying forms of evidence be evaluated for meaning?
How does technology help bring resolution to forensic cases? Or how does technology advance the understandings in forensic science?
How can the cause, mechanism, and manner of death be established?
What information can be collected from an autopsy?</td></tr>
</table>

	collaborative, and solution-driven nature of the profession. Biomedical Science requires effective communication with a variety of audiences using multiple modalities. Being able to effectively and efficiently function on multidisciplinary teams is critical to success in the biomedical sciences. The practice of biomedical sciences requires the application of common tools, techniques, and technologies to solve problems. Patient records and other pieces of medical evidence can be used to assess a person's health and identify disease. Analyzing DNA offers insight into human identity and the causes of genetic diseases. Biomedical scientists study and manipulate microorganisms to understand their properties (i.e., growth and behavior) and their role in infectious disease. Understanding the proper function of cells can help determine when something goes wrong. Biomedical scientists need to understand how the body functions in order to support patient health.	How can information collected during an autopsy lead to an understanding of disease and/or cause of death? In what ways are the careful evaluation of evidence and accurate recording of data critical to establishing legitimate testimony? How can individual pieces of evidence, evaluated against the whole, be used to resolve questions? In what ways can scientific writings and presentations be utilized to present evidence and justify conclusions? To what extent can current understandings be reinforced through practice?
Learning Targets		

Course Name: PLTW Principles of Biomedical Science

Students will…

(These are the nouns in your standards. What will your students have to learn using this standard?)

Conduct background research using credible sources to identify and investigate a relevant research question.
Develop a testable hypothesis and design an experimental protocol that evaluates its validity.
Distinguish between independent and dependent variables.
Identify and explain the purpose and importance of experimental controls.
Select and use equipment appropriately to conduct experiments.
Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.
Identify possible sources of errors, then redesign and repeat the experiment when appropriate.
Display experimental data appropriately and accurately in digital or written form (graphs, tables, diagrams).
Perform necessary calculations to analyze experimental data.
Draw logical conclusions from experimental data.
Communicate experimental findings with appropriate audiences both orally and in writing.
Devise and execute a plan to solve a problem while considering the impacts of the possible solutions.
Use mathematical computations to interpret data.
Collect, display, analyze, and interpret data (including diagrams, charts, graphs, and tables) to draw a conclusion.
Conduct research using credible resources to craft explanations and draw conclusions while acknowledging the limitations, opposing views, and biases.
Assess how design and innovation can help solve a problem in biomedical science.
Identify and define visual, functional, and structural design requirements (criteria) and realistic constraints, against which solution alternatives can be evaluated and optimized.
Compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.
Develop a solution and implement a plan to test and evaluate a potential solution to verify that it meets all constraints and complies with all design criteria.
Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.
Describe the education requirements, salary ranges, professional licensure, skills, and/or responsibilities of biomedical science professionals.
Describe the impact that biomedical science research and interventions have on society.
Demonstrate professional standards, such as creativity, perseverance, honesty, integrity, and accountability, which should be exhibited by biomedical professionals.
Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.
Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.
Weigh the ethical implications of biomedical science decisions.

Course Name: PLTW Principles of Biomedical Science

Summarize and explain the larger ethical, moral, and legal issues related to scientific research, product development, and use in society (animal use/human research).
Follow acceptable formats for writing assignments and professional presentations.
Modify communications to meet the needs of the audience or patient.
Apply listening skills and interpret verbal and nonverbal behaviors to enhance communication with coworkers and patients.
Use proper elements of written and electronic communication (spelling, grammar, and formatting).
Use appropriate scientific terminology and abbreviations.
Respect others' viewpoints.
Demonstrate teamwork and describe the importance of each team member's contribution to the project.
Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.
Demonstrate appropriate peer review processes for asking questions and giving effective and constructive feedback.
Develop a project schedule allocating tasks among team members, and track progress for successful completion of the project.
Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.
Use and apply principles of measurement.
Develop and utilize a standard curve.
Practice precise and accurate micropipetting.
Demonstrate proper use of a microscope to view biological samples.
Demonstrate aseptic technique.
Practice culturing techniques.
Demonstrates an ability to accurately follow a lab protocol.
Use medical terminology to transcribe and communicate information, data, and observations.
Maintain accurate patient records and demonstrate why this is important.
Collect, assess and interpret patient vital signs.
Select and use appropriate diagnostic tools and tests to evaluate a patient's condition.
Interpret medical information and/or laboratory test results to draw conclusions.
Identify causes (environmental, genetic, lifestyle, and the like) of health conditions.
Describe how a condition or disorder impacts body systems.
Prescribe a viable course of action to treat or manage a condition.
Describe the impact of lifestyle habits on human health and disease risk.
Describe the structure and function of nucleic acids and the relationship among genes, alleles, chromosomes, proteins, and traits.

Explain and demonstrate techniques in molecular biology (DNA extraction, restriction digestion, gel electrophoresis) and interpret results. *Employ immunological techniques for identification and diagnosis.* *Differentiate between prokaryotic and eukaryotic cells.* *Describe the relationship of cells, tissues, organs, and systems in the human body.* *Identify the structure and function of macromolecules that are used in the body.* *Interpret the interaction between cells, and between cells and their environment.* *Describe the anatomy and physiology of key human body systems as well as the organization and interaction of these systems.* *Understand that interactions between internal and external sources can affect body systems and cell functions.* *Explain how organ anatomy (such as that of the heart or brain) is related to function.* *Demonstrate how a change in structure in the body impacts function.* *Cite examples of how body systems collaboratively function to maintain homeostasis and health.* *Create, describe, and analyze models of biological processes to explain proper and improper functioning.*
Unit Duration:
18-20 blocks

Unit [2]: [Clinical Care]
Desired Results

Standards	Transfer Goal(s) /Big Ideas	
[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard) **Missouri Learning Standards**	*Copy goals from the course overview page that fit this unit. (This will be more abstract than the Enduring Understandings)* *Students assume the role of different medical professionals working through the schedule of patients in a family care clinic in order to: a.) explore medical careers; b.) practice professional communication; c.) gain experience collecting, recording, and interpreting physiological data; d.) learn how to perform routine medical tests and evaluate results; e.) learn about cutting edge technologies revolutionizing healthcare; f.) understand the interconnectedness between body systems; and g.) explore the various causations and inheritance of disease.*	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? An experimental design process is a systematic approach to investigate and gain knowledge. Biomedical science professionals approach complex problems systematically and logically by breaking them into manageable components. They work collaboratively and apply their knowledge and skills to draw well-reasoned conclusions and solutions. Biomedical science solutions have global impacts in economic, environmental, and societal contexts.	*What are essential Questions?* How can an individual's health status be assessed and evaluated? What factors make an individual more susceptible to disease? What are strategies for maintaining health? What are effective means of communicating with others in order to reach common goals? What qualities make for an effective medical professional? In what ways, and for what purpose, can patient confidentiality be maintained? How can changes in a genome lead to disease?

	Successful biomedical scientists typically exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of the profession. Biomedical Science requires effective communication with a variety of audiences using multiple modalities. Being able to effectively and efficiently function on multidisciplinary teams is critical to success in the biomedical sciences. The practice of biomedical sciences requires the application of common tools, techniques, and technologies to solve problems. Patient records and other pieces of medical evidence can be used to assess a person's health and identify disease. Analyzing DNA offers insight into human identity and the causes of genetic diseases. Understanding the proper function of cells can help determine when something goes wrong. Biomedical scientists need to understand how the body functions in order to support patient health.	Why is an understanding of heredity an important factor in human health? In what ways are genetic changes acquired? In what ways can altered biological processes lead to disease? How can the genetic health of an individual be evaluated?

Learning Targets

Students will…

(These are the nouns in your standards. What will your students have to learn using this standard?)

Conduct background research using credible sources to identify and investigate a relevant research question.

Identify and explain the purpose and importance of experimental controls.

Select and use equipment appropriately to conduct experiments.
Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.
Identify possible sources of errors, then redesign and repeat the experiment when appropriate.
Display experimental data appropriately and accurately in digital or written form (graphs, tables, diagrams).
Perform necessary calculations to analyze experimental data.
Draw logical conclusions from experimental data.
Communicate experimental findings with appropriate audiences both orally and in writing.
Synthesize information from multiple credible sources, such as literature, databases, policy documents, and diverse perspectives from multiple disciplines, to explore causes and solutions to problems.
Use mathematical computations to interpret data.
Collect, display, analyze, and interpret data (including diagrams, charts, graphs, and tables) to draw a conclusion.
Conduct research using credible resources to craft explanations and draw conclusions while acknowledging the limitations, opposing views, and biases.
Assess how design and innovation can help solve a problem in biomedical science.
Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.
Describe the education requirements, salary ranges, professional licensure, skills, and/or responsibilities of biomedical science professionals.
Describe the impact that biomedical science research and interventions have on society.
Demonstrate professional standards, such as creativity, perseverance, honesty, integrity, and accountability, which should be exhibited by biomedical professionals.
Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.
Weigh the ethical implications of biomedical science decisions.
Summarize and explain the larger ethical, moral, and legal issues related to scientific research, product development, and use in society (animal use/human research).
Follow acceptable formats for writing assignments and professional presentations.
Modify communications to meet the needs of the audience or patient.
Apply listening skills and interpret verbal and nonverbal behaviors to enhance communication with coworkers and patients.
Use proper elements of written and electronic communication (spelling, grammar, and formatting).
Demonstrate technical reading and writing by reading scientific journal articles and demonstrating knowledge of databases (PubMed, NCBI), and writing scientific lab reports.
Use appropriate scientific terminology and abbreviations.
Respect others' viewpoints.

Course Name: PLTW Principles of Biomedical Science

Demonstrate teamwork and describe the importance of each team member's contribution to the project.
Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.
Demonstrate appropriate peer review processes for asking questions and giving effective and constructive feedback.
Develop a project schedule allocating tasks among team members, and track progress for successful completion of the project.
Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.
Use and apply principles of measurement.
Calculate concentrations and/or prepare solutions.
Practice precise and accurate micropipetting.
Demonstrate proper use of a microscope to view biological samples.
Demonstrate aseptic technique.
Demonstrates an ability to accurately follow a lab protocol.
Use medical terminology to transcribe and communicate information, data, and observations.
Maintain accurate patient records and demonstrate why this is important.
Demonstrate adherence to HIPAA guidelines to maintain patient privacy.
Collect, assess and interpret patient vital signs.
Select and use appropriate diagnostic tools and tests to evaluate a patient's condition.
Interpret medical information and/or laboratory test results to draw conclusions.
Identify causes (environmental, genetic, lifestyle, and the like) of health conditions.
Describe how a condition or disorder impacts body systems.
Prescribe a viable course of action to treat or manage a condition.
Describe the impact of lifestyle habits on human health and disease risk.
Describe measures to prevent disease, disorder, or injury, such as regular doctor's visits and screening tests.
Describe the structure and function of nucleic acids and the relationship among genes, alleles, chromosomes, proteins, and traits.
Explain how the order and chemical properties of amino acids influence a protein's structure and function.
Describe the processes of DNA replication and protein synthesis.
Explain how mutations in nucleic acids can lead to diseases or disorders or promote evolutionary change.
Demonstrate how environmental factors can lead to genetic mutations.
Differentiate between mitosis and meiosis and model how these processes lead to genetic diversity.
Analyze karyotypes to diagnose chromosomal abnormalities.
Predict the pattern of gene inheritance using Punnett squares.

Predict the pattern of gene inheritance using pedigree analysis. *Explain and demonstrate techniques in molecular biology (DNA extraction, restriction digestion, gel electrophoresis) and interpret results.* *Utilize bioinformatics to analyze and compare genetic information.* *Differentiate between prokaryotic and eukaryotic cells.* *Describe the relationship of cells, tissues, organs, and systems in the human body.* *Identify the structure and function of macromolecules that are used in the body.* *Interpret the interaction between cells, and between cells and their environment.* *Describe the anatomy and physiology of key human body systems as well as the organization and interaction of these systems.* *Understand that interactions between internal and external sources can affect body systems and cell functions.* *Explain how organ anatomy (such as that of the heart or brain) is related to function.* *Demonstrate how a change in structure in the body impacts function.* *Cite examples of how body systems collaboratively function to maintain homeostasis and health.* *Demonstrate how feedback loops help maintain homeostasis in the body.* *Create, describe, and analyze models of biological processes to explain proper and improper functioning.*
Unit Duration:
18-20 blocks

<table>
<tr><th colspan="3">Unit [3]: [Outbreaks and Emergencies]
Desired Results</th></tr>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="3">[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard)

Missouri Learning Standards</td><td colspan="2">Copy goals from the course overview page that fit this unit. (This will be more abstract than the Enduring Understandings)
Working as public health officials and then as emergency responders, students are presented with a series of events they must address while exploring: a.) careers in public health, epidemiology, microbiology and emergency medicine; b.) professional communication and presentation; c.) data analysis; d.) processes by which critical medical decisions are made and acted upon; e.) processes by which patients are diagnosed with a contagious disease and by which a causative agent is identified.</td></tr>
<tr><th>Enduring Understandings</th><th>Essential Questions</th></tr>
<tr><td>What are enduring understandings?
An experimental design process is a systematic approach to investigate and gain knowledge.
Biomedical science professionals approach complex problems systematically and logically by breaking them into manageable components. They work collaboratively and apply their knowledge and skills to draw well-reasoned conclusions and solutions.
Biomedical science solutions have global impacts in economic, environmental, and societal contexts.</td><td>What are essential Questions?
In what ways, and for what purpose, can microorganisms be characterized?
What factors affect the growth and death of microorganisms?
What are effective strategies for preventing and treating disease?
How does an immune system identify and eradicate infection?
How can pieces of evidence be evaluated to form conclusions and inform decisions?</td></tr>
</table>

	Successful biomedical scientists typically exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of the profession. Biomedical Science requires effective communication with a variety of audiences using multiple modalities. Being able to effectively and efficiently function on multidisciplinary teams is critical to success in the biomedical sciences. The practice of biomedical sciences requires the application of common tools, techniques, and technologies to solve problems. Patient records and other pieces of medical evidence can be used to assess a person's health and identify disease. Biomedical scientists study and manipulate microorganisms to understand their properties (i.e., growth and behavior) and their role in infectious disease. Understanding the proper function of cells can help determine when something goes wrong. Biomedical scientists need to understand how the body functions in order to support patient health.	How can an individual's health status be assessed and evaluated? How is patient case information summarized and communicated efficiently? What professions respond in emergency situations, what are their roles, and how do they work together? What are several career paths in the field of emergency medicine? How do patient vitals and presumptive diagnoses inform the prioritization for treatment options in emergency medical situations? What makes for effective emergency and disaster response protocols? How do medical professionals manage emergencies that involve multiple patients? To respond to emergency situations, what common medical resources and facilities need to be available? What are features of a user-friendly app? In what ways can technology enable a faster response and quicker resolution during medical emergencies?
Learning Targets		

Course Name: PLTW Principles of Biomedical Science

Students will…

(These are the nouns in your standards. What will your students have to learn using this standard?)

Conduct background research using credible sources to identify and investigate a relevant research question.

Select and use equipment appropriately to conduct experiments.

Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.

Identify possible sources of errors, then redesign and repeat the experiment when appropriate.

Display experimental data appropriately and accurately in digital or written form (graphs, tables, diagrams).

Perform necessary calculations to analyze experimental data.

Draw logical conclusions from experimental data.

Communicate experimental findings with appropriate audiences both orally and in writing.

Synthesize information from multiple credible sources, such as literature, databases, policy documents, and diverse perspectives from multiple disciplines, to explore causes and solutions to problems.

Devise and execute a plan to solve a problem while considering the impacts of the possible solutions.

Use mathematical computations to interpret data.

Collect, display, analyze, and interpret data (including diagrams, charts, graphs, and tables) to draw a conclusion.

Conduct research using credible resources to craft explanations and draw conclusions while acknowledging the limitations, opposing views, and biases.

Assess how design and innovation can help solve a problem in biomedical science.

Identify and define visual, functional, and structural design requirements (criteria) and realistic constraints, against which solution alternatives can be evaluated and optimized.

Compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.

Develop a solution and implement a plan to test and evaluate a potential solution to verify that it meets all constraints and complies with all design criteria.

Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.

Describe the education requirements, salary ranges, professional licensure, skills, and/or responsibilities of biomedical science professionals.

Describe the impact that biomedical science research and interventions have on society.

Demonstrate professional standards, such as creativity, perseverance, honesty, integrity, and accountability, which should be exhibited by biomedical professionals.

Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.

Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.

Weigh the ethical implications of biomedical science decisions.

Follow acceptable formats for writing assignments and professional presentations.

Modify communications to meet the needs of the audience or patient.
Apply listening skills and interpret verbal and nonverbal behaviors to enhance communication with coworkers and patients.
Use proper elements of written and electronic communication (spelling, grammar, and formatting).
Demonstrate technical reading and writing by reading scientific journal articles and demonstrating knowledge of databases (PubMed, NCBI), and writing scientific lab reports.
Use appropriate scientific terminology and abbreviations.
Respect others' viewpoints.
Demonstrate teamwork and describe the importance of each team member's contribution to the project.
Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.
Demonstrate appropriate peer review processes for asking questions and giving effective and constructive feedback.
Develop a project schedule allocating tasks among team members, and track progress for successful completion of the project.
Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.
Use and apply principles of measurement.
Calculate concentrations and/or prepare solutions
Demonstrate proper use of a microscope to view biological samples.
Demonstrate aseptic technique.
Practice culturing techniques.
Demonstrates an ability to accurately follow a lab protocol.
Use medical terminology to transcribe and communicate information, data, and observations.
Maintain accurate patient records and demonstrate why this is important.
Demonstrate adherence to HIPAA guidelines to maintain patient privacy.
Collect, assess and interpret patient vital signs.
Select and use appropriate diagnostic tools and tests to evaluate a patient's condition.
Interpret medical information and/or laboratory test results to draw conclusions.
Identify causes (environmental, genetic, lifestyle, and the like) of health conditions.
Describe how a condition or disorder impacts body systems.
Prescribe a viable course of action to treat or manage a condition.
Demonstrate appropriate public health measures by proposing strategies for responding to health crises and/or disasters.
Describe measures to prevent disease, disorder, or injury, such as regular doctor's visits and screening tests.
Identify the structures of bacterial cells and viruses.

Characterize and identify bacteria by their shape, colony morphology, metabolism, and reaction to the Gram stain. *Describe the mode of transmission and reproduction of various infectious agents.* *Describe the prevention and treatment of infectious disease.* *Describe how the immune system responds when an antigen enters the body.* *Describe immune-based prevention of and treatment for various infectious agents.* *Differentiate between prokaryotic and eukaryotic cells.* *Describe the relationship of cells, tissues, organs, and systems in the human body.* *Identify the structure and function of macromolecules that are used in the body.* *Demonstrate how the structure of the cell membrane impacts homeostasis.* *Interpret the interaction between cells, and between cells and their environment.* *Describe the anatomy and physiology of key human body systems as well as the organization and interaction of these systems.* *Understand that interactions between internal and external sources can affect body systems and cell functions.* *Demonstrate how a change in structure in the body impacts function.* *Cite examples of how body systems collaboratively function to maintain homeostasis and health.* *Demonstrate how feedback loops help maintain homeostasis in the body.* *Create, describe, and analyze models of biological processes to explain proper and improper functioning.*
Unit Duration:
18-20 blocks

Unit [4]: [Innovation, Inc.]
Desired Results

Standards	Transfer Goal(s) /Big Ideas	
[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard) **Missouri Learning Standards**	*Copy goals from the course overview page that fit this unit. (This will be more abstract than the Enduring Understandings)* *Welcome to PLTW Innovation, Inc. – an incubator for innovation where some of the best minds in science and engineering endeavor to solve some of the world's most pressing biomedical challenges. Students tour Innovation, Inc. labs and engage in experiences designed to: a.) build their engineering and experimental design process skills, b.) challenge them to design solutions to current and emerging issues both on and off this world, c.) tangibly highlight that solutions to biomedical science problems rely on collaboration between professions, d.) build their computer science skills by using computer aided design (CAD) and geographic information system (GIS) to innovate the future of medicine, and e.) explore career fields on the forefront of medicine.*	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? An experimental design process is a systematic approach to investigate and gain knowledge. Biomedical science professionals approach complex problems systematically and logically by breaking them into manageable components. They work collaboratively and apply their	*What are essential Questions?* How do the engineering and experimental design processes enable innovation? Who innovates, and why? What is the process for innovation and what personal characteristics are required for success?

	knowledge and skills to draw well-reasoned conclusions and solutions. Biomedical science solutions have global impacts in economic, environmental, and societal contexts. Successful biomedical scientists typically exhibit specific personal and professional characteristics that lend themselves to the creative, collaborative, and solution-driven nature of the profession. Biomedical Science requires effective communication with a variety of audiences using multiple modalities. Being able to effectively and efficiently function on multidisciplinary teams is critical to success in the biomedical sciences. The practice of biomedical sciences requires the application of common tools, techniques, and technologies to solve problems. Patient records and other pieces of medical evidence can be used to assess a person's health and identify disease. Biomedical scientists study and manipulate microorganisms to understand their properties (i.e., growth and behavior) and their role in infectious disease. Biomedical scientists need to understand how the body functions in order to support patient health.	How do innovations impact and advance human health? How does technology function as a vehicle for innovation? In what ways do different types of scientists and engineers collaborate in the biomedical sciences field? What are potential untapped resources that could work to advance the field of biomedical sciences?

Course Name: PLTW Principles of Biomedical Science

Learning Targets
Students will… ***(These are the nouns in your standards. What will your students have to learn using this standard?)*** *Conduct background research using credible sources to identify and investigate a relevant research question.* *Identify and explain the purpose and importance of experimental controls.* *Select and use equipment appropriately to conduct experiments.* *Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.* *Identify possible sources of errors, then redesign and repeat the experiment when appropriate.* *Display experimental data appropriately and accurately in digital or written form (graphs, tables, diagrams).* *Draw logical conclusions from experimental data.* *Communicate experimental findings with appropriate audiences both orally and in writing.* *Synthesize information from multiple credible sources, such as literature, databases, policy documents, and diverse perspectives from multiple disciplines, to explore causes and solutions to problems.* *Devise and execute a plan to solve a problem while considering the impacts of the possible solutions.* *Collect, display, analyze, and interpret data (including diagrams, charts, graphs, and tables) to draw a conclusion.* *Conduct research using credible resources to craft explanations and draw conclusions while acknowledging the limitations, opposing views, and biases.* *Assess how design and innovation can help solve a problem in biomedical science.* *Identify and define visual, functional, and structural design requirements (criteria) and realistic constraints, against which solution alternatives can be evaluated and optimized.* *Compare competing solution ideas and justify the selection of a solution path with respect to design requirements and constraints.* *Develop a solution and implement a plan to test and evaluate a potential solution to verify that it meets all constraints and complies with all design criteria.* *Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.* *Describe the education requirements, salary ranges, professional licensure, skills, and/or responsibilities of biomedical science professionals.* *Describe the impact that biomedical science research and interventions have on society.* *Demonstrate professional standards, such as creativity, perseverance, honesty, integrity, and accountability, which should be exhibited by biomedical professionals.* *Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.* *Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.* *Weigh the ethical implications of biomedical science decisions.*

Course Name: PLTW Principles of Biomedical Science

Summarize and explain the larger ethical, moral, and legal issues related to scientific research, product development, and use in society (animal use/human research).
Follow acceptable formats for writing assignments and professional presentations.
Modify communications to meet the needs of the audience or patient.
Apply listening skills and interpret verbal and nonverbal behaviors to enhance communication with coworkers and patients.
Properly cite references for all reports in an accepted format.
Use proper elements of written and electronic communication (spelling, grammar, and formatting).
Demonstrate technical reading and writing by reading scientific journal articles and demonstrating knowledge of databases (PubMed, NCBI), and writing scientific lab reports.
Use appropriate scientific terminology and abbreviations.
Respect others' viewpoints.
Demonstrate teamwork and describe the importance of each team member's contribution to the project.
Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.
Demonstrate appropriate peer review processes for asking questions and giving effective and constructive feedback.
Develop a project schedule allocating tasks among team members, and track progress for successful completion of the project.
Select and use collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.
Use and apply principles of measurement.
Develop and utilize a standard curve.
Practice precise and accurate micropipetting.
Demonstrate aseptic technique.
Demonstrates an ability to accurately follow a lab protocol.
Use medical terminology to transcribe and communicate information, data, and observations.
Collect, assess and interpret patient vital signs.
Interpret medical information and/or laboratory test results to draw conclusions.
Identify causes (environmental, genetic, lifestyle, and the like) of health conditions.
Describe how a condition or disorder impacts body systems.
Prescribe a viable course of action to treat or manage a condition.
Describe the impact of lifestyle habits on human health and disease risk.
Describe measures to prevent disease, disorder, or injury, such as regular doctor's visits and screening tests.
Describe how the immune system responds when an antigen enters the body.

Describe the anatomy and physiology of key human body systems as well as the organization and interaction of these systems. *Understand that interactions between internal and external sources can affect body systems and cell functions.* *Explain how organ anatomy (such as that of the heart or brain) is related to function.* *Demonstrate how a change in structure in the body impacts function.* *Cite examples of how body systems collaboratively function to maintain homeostasis and health.* *Create, describe, and analyze models of biological processes to explain proper and improper functioning.*
Unit Duration:
14-16 blocks

[PLTW-Biomedical Innovations (Yr. 4)] ***Course Overview***	
Grade level(s): 11-12	**Credits earned:** 0.5 credits of weighted high school science credit per semester with the potential to earn college credit through Missouri S&T if certain criteria are met.
Course Rationale	**Course Description**
In the Biomedical Innovation course, students will be asked to apply what they have learned in the previous three courses to solve unique problems in science, medicine, and healthcare. Students will work systematically through required problems before completing optional directed problems or independent work. Each problem is staged as a mission – a unique set of tasks the students must work through to achieve their desired objective. Students are presented with each problem in a Mission File – a document that includes a case brief, a list of completion tasks, links to available resources, as well as a reflection section. Working through the missions not only exposes students to current issues in biomedical science, but it also provides skills-based instruction in research and experimentation – tools students will use to design innovative solutions to real-world problems. Students will use what they learn in these missions as they develop and implement their independent project at the end of the year. A teacher may use additional resources in the community – the guidance of other teachers in the school, the advice of scientists or biomedical professionals, or the knowledge presented in scientific literature to help students achieve each goal.	In this capstone course, students apply their knowledge and skills to answer questions or solve problems related to the biomedical sciences. Students design innovative solutions for the health challenges of the 21st century as they work through progressively challenging open-ended problems, addressing topics such as clinical medicine, physiology, biomedical engineering, and public health. They have the opportunity to work on an independent project and may work with a mentor or advisor from a university, hospital, physician's office, or industry. Throughout the course, students are expected to present their work to an adult audience that may include representatives from the local business and healthcare community.

Transfer Goals/Big Ideas
What are transfer Goals/ Big Ideas? ● Asking Questions and Defining Problems ● Developing and using models ● Planning and carrying out investigations ● Analyzing and interpreting data ● Using mathematics and computational thinking ● Constructing explanations and designing solutions ● Engaging in an argument from evidence ● Obtaining, evaluating, and communication information
Priority Missouri Learning Standards/National Standards
Missouri Learning Standards***(NGSS)*** ● ***HS.LS2.7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** ● ***HS.LS4.6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** ● ***HS.ESS3.1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*** ● ***HS.ESS3.4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** ● ***HS.ETS1.1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*** ● ***HS.ETS1.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*** ● ***HS.ETS1.3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.***

Problem [1]: [Design of an Effective Emergency Room]
Desired Results

Standards	Transfer Goal(s) /Big Ideas	
[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard) Missouri Learning Standards*(NGSS)* ● ***ETS1.2*** ● ***ETS1.3***	***In this problem students apply their knowledge of emergency medical careers, diagnostic testing and patient evaluation, human body systems, and medical interventions to analyze the workings of an emergency room and discuss inefficiencies that may hinder appropriate clinical care. Student teams will work collaboratively to design a more efficient emergency medicine delivery system. As students work through their designs, they will review research methods, practice effective presentation skills, and learn project management techniques.***	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? ● ***Solve a problem using analytical and critical thinking skills.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain why scientists must have the courage to take a calculated risk.*** ● ***Design a medical space that is conducive to patient wellness and improves patient outcomes.*** ● ***Create or improve a medical innovation using a design process.*** ● ***Analyze health and disease data to inform public health decisions.***	*What are essential Questions?* 1. What are the top health-related challenges of the 21st century? 2. What process do biomedical scientists follow to solve a problem in health, medicine, or science? 3. How can you determine whether the information presented on a website is accurate and credible? 4. What factors must be considered when designing and delivering an oral or visual presentation? 5. What factors are considered in the triage of patients in an emergency room?

	● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	6. How can the innovative design of an emergency room help improve the quality and timeliness of medical care?

Learning Targets

Students will…

- ***Devise and execute a plan to solve a problem.***
- ***Explain the importance of collecting data from multiple sources for a problem.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Describe how medical innovations can reduce wait time in the emergency room.***

- ***Design an efficient emergency room to reduce patient wait time.***
- ***Determine how patient health issues are prioritized in an emergency room.***
- ***Describe the impact of various medical innovations on human health.***
- ***Analyze medical evidence to diagnose a patient's health condition.***
- ***Identify medical interventions that can address global health issues.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Describe the unique solutions to the health and medical problems of this century.***
- ***Describe the global impact of biomedical science solutions.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Produce a Gantt chart to manage the work of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Explain the advantages and disadvantages of using online resources.***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***
- ***Employ a peer review process to give effective and constructive feedback to meet given outcomes.***

Course Name: PLTW-Biomedical Innovations (Yr. 4)

Unit Duration:
21.75 days



Problem [2]: [Exploring Human Physiology]
Desired Results

<table>
<tr><th>Standards</th><th colspan="2">Transfer Goal(s) /Big Ideas</th></tr>
<tr><td rowspan="2">Missouri Learning Standards(NGSS)
● ETS1.2
● ETS1.3</td><td colspan="2">In this problem students build upon what they know about the research process in order to design, conduct, and analyze an experimental study. Students will choose a question relating to one or more body systems that they are interested in studying and will work with a team to investigate and answer that question. As students work through the experimental process, they will review and expand what they know about experimental design, collection of data, statistical analysis of data, and the presentation of data.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td></td><td>What are enduring understandings?
● Design an experiment that investigates a research question.
● Collect and analyze data to draw a conclusion.
● Solve a problem using analytical and critical thinking skills.
● Explain why scientists must have the courage to take a calculated risk.
● Select and use appropriate tools, technology, and/or software for</td><td>What are essential Questions?
1. How do scientists design research studies to find the most accurate answer to the question they are asking?
2. How can statistics be used to manipulate data?
3. How do research results presented in the popular media differ from research results presented in scientific literature?</td></tr>
</table>

	experimental and clinical data collection and analysis. ● ***Use statistics to solve biomedical science problems.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	4. How do scientists use statistical analyses to draw meaningful conclusions from experimental results?

Learning Targets

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Distinguish between the independent and dependent variables.***
- ***Identify and explain the purpose and importance of experimental controls.***
- ***Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***

- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, then redesign and repeat the experiment when appropriate.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Select appropriate technology and software for data collection.***
- ***Use probes and software to conduct investigations and analyze data.***
- ***Conduct two sample t-tests to analyze data.***
- ***Explain how data can be manipulated in scientific studies.***
- ***Discuss how scientific data is presented in the media and in scientific journals.***
- ***Describe how statistics can be used inappropriately to manipulate data and/or mislead readers.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Produce a Gantt chart to manage the work of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***

- ***Explain the importance of privacy for all individuals. Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Describe the ethics of human experimentation and the importance of informed consent.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Explain the advantages and disadvantages of using online resources.***
- ***Prepare and present a poster on key information from a scientific study.***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:
21.75 days

Problem [3]: [Design of a Medical Innovation]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**
Missouri Learning Standards*(NGSS)* • ***ETS1.2*** • ***ETS1.3***	***In this problem students review the diseases and disorders, as well as the corresponding medical interventions they have investigated in the previous courses, and propose a new or better medical device, pharmaceutical, surgical procedure, or genetic intervention. Students will work with a team to build a prototype, model, or schematic of the intervention as well as develop a marketing plan for the product. As students work through this problem, they will review the design process, complete a***

	literature review, and further practice effective presentation skills.	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw a conclusion.*** ● ***Solve a problem using analytical and critical thinking skills.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain why scientists must have the courage to take a calculated risk.*** ● ***Create or improve a medical innovation using a design process.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.***	*What are essential Questions?* 1. How is the design process used to create a new product or system? 2. What criteria need to be specified when designing a solution to a problem? 3. What factors need to be considered when designing a marketing plan for a new product?How does the development of cancer relate to the cell cycle?

	● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	

Learning Targets

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Build a model, prototype, or schematic of proposed designs.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Explain the importance of collecting data from multiple sources for a problem.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Describe the impact of various medical innovations on human health.***
- ***Discuss the process of inventing and improving medical innovations.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***

- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Describe the unique solutions to the health and medical problems of this century.***
- ***Describe the global impact of biomedical science solutions.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Explain the advantages and disadvantages of using online resources.***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:

21.75 days

Problem [4]: [How to Prevail When Organs Fail]
Desired Results

Standards	Transfer Goal(s) /Big Ideas
Missouri Learning Standards*(NGSS)* ● ***LS2.7*** ● ***LS4.6*** ● ***ESS3.1*** ● ***ESS3.4*** ● ***ETS1.1*** ● ***ETS1.2*** ● ***ETS1.3***	***In this problem students will explore how substances or chemicals in the environment impact human health. Students will investigate a disease cluster in a fictional family and assess the activities of the individuals for environmental risks. Students will test water samples for the presence of contaminants that could be detrimental to human health and use molecular biology techniques to identify specific microorganisms. Students will explore the field of toxicology and design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. Students will then compile a comprehensive environmental health profile and action plan for their local area.***

Enduring Understandings	Essential Questions
What are enduring understandings? ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw a conclusion.*** ● ***Solve a problem using analytical and critical thinking skills.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain why scientists must have the courage to take a calculated risk.*** ● ***Select and use appropriate tools, technology, and/or software for***	*What are essential Questions?* 4. How does the environment affect human health? 5. Why is it important to routinely test water that is used for drinking or recreational purposes? 6. What factors affect how individuals respond to a given toxin? 7. How can individuals alter their lifestyle to limit human impact on the environment? 8. How might a study of trends in health in a particular community identify potential environmental contaminants?

	experimental and clinical data collection and analysis. ● ***Evaluate the impact of environmental factors on human health.*** ● ***Use proper techniques to identify strains of bacteria.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	

Learning Targets

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Distinguish between the independent and dependent variables.***
- ***Identify and explain the purpose and importance of experimental controls.***

- ***Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, then redesign and repeat the experiment when appropriate.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Explain the importance of collecting data from multiple sources for a problem.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Select appropriate technology and software for data collection.***
- ***Describe and demonstrate aseptic techniques for handling, culturing, and analyzing bacteria colonies.***
- ***Conduct gel electrophoresis to separate DNA fragments.***
- ***Identify environmental concerns that are potentially harmful to health.***
- ***Explain how various factors affect how individuals respond to a given toxin.***
- ***Design and conduct water quality testing for the presence of contaminants.***
- ***Create an environmental health profile and action plan for the local area.***
- ***Create and analyze a dose response model for the exposure of toxic chemicals.***
- ***Conduct water quality testing for the presence of coliforms and E. coli.***
- ***Analyze bacterial DNA using PCR and gel electrophoresis to identify the strains.***

- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Describe the unique solutions to the health and medical problems of this century.***
- ***Describe the global impact of biomedical science solutions.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Describe the ethics of human experimentation and the importance of informed consent.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Explain the advantages and disadvantages of using online resources.***
- ***1 Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:

21.75 days

Course Name: PLTW-Biomedical Innovations (Yr. 4)

<table>
<tr><td colspan="3">Problem [5]: [Combating a Public Health Issue]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="2">Missouri Learning Standards(NGSS)
● ETS1.1
● ETS1.2
● ETS1.3</td><td colspan="2">In this problem students draw on information they have learned in the previous courses about public health, epidemiology, and disease diagnosis to work through one of two epidemiology studies. In each study students will analyze data to define the outbreak, generate a hypothesis by diagnosing the patients' symptoms and identifying the disease pathogen, design and analyze an epidemiological study to test the hypothesis, and outline a plan for initiating control and prevention measures. Students will then identify a local, national, or global public health crisis and write a mini-grant proposal, based on the National Institutes of Health grant structure, outlining a plan with intervention strategies. As students work through this problem, they will review evidence analysis, the design process, methodology, and analyze study data to evaluate risk.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>What are enduring understandings?
● Collect and analyze data to draw a conclusion.
● Solve a problem using analytical and critical thinking skills.
● Explain the value of diverse perspectives in the problem-solving process.
● Explain why scientists must have the courage to take a calculated risk.
● Create or improve a medical innovation using a design process.</td><td>What are essential Questions?
1. How do epidemiologists investigate a potential disease outbreak?
2. What factors determine when to use a case-control versus a cohort study?
3. How does causation differ from correlation?
4. How does the distribution of infectious disease and chronic illnesses in a given area relate to lifestyle, culture, and access to medical care?</td></tr>
</table>

	● ***Analyze health and disease data to inform public health decisions.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	5. What factors determine who receives funding for health related projects or research studies?

Learning Targets

Students will…

- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Explain the importance of collecting data from multiple sources for a problem.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***

- ***Describe the impact of various medical innovations on human health.***
- ***Analyze medical evidence to diagnose a patient's health condition.***
- ***Analyze data from epidemiological studies to investigate the symptoms, pathogen, and transmission pattern of a mystery illness.***
- ***Identify medical interventions that can address global health issues.***
- ***Calculate measures of risk used to demonstrate a possible association between a risk factor and a disease.***
- ***Describe how to set up case-control and cohort studies.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Describe the unique solutions to the health and medical problems of this century.***
- ***Describe the global impact of biomedical science solutions.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Write a mini grant to fund a proposal using a specified format (ex: National Institutes of Health).***
- ***Explain the advantages and disadvantages of using online resources.***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Course Name: PLTW-Biomedical Innovations (Yr. 4)

Unit Duration:
21.75 days

Problem [6]: [Molecular Biology in Action]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**	
Missouri Learning Standards*(NGSS)* ● ***ETS1.1*** ● ***ETS1.3***	***In this problem students will complete a multi-step, long-term molecular biology experiment. Students will design and work through a protocol to construct and clone recombinant DNA. They will perform DNA ligation and bacterial transformation, as well as restriction analysis of the completed plasmid. Alternatively, students will work through a more in-depth DNA cloning and sequencing project. This laboratory investigation provides students with the opportunity to isolate plant DNA, perform a ligation and bacterial transformation, purify a plasmid, submit DNA for sequencing, and present all work to GenBank, the NIH genetic sequence database, for publication. As students work through either of these projects, they will learn new laboratory skills, practice laboratory troubleshooting techniques, and review proper protocol for research notebook documentation.***	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw a conclusion.***	*What are essential Questions?* 1. How can plasmids be used in the lab to clone a gene of interest? 2. Why are restriction enzymes a fundamental molecular biology tool?

	● ***Solve a problem using analytical and critical thinking skills.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain why scientists must have the courage to take a calculated risk.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Demonstrate awareness of the societal impacts of biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	3. How might molecular biology shape the future of pharmacology and medicine? 4. Is there such a thing as knowing too much about your personal genetic makeup?
Learning Targets		

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Maintain a detailed repeatable account of the experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, then redesign and repeat the experiment when appropriate.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Collaborate with a mentor who is an expert in their field.***
- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Select appropriate technology and software for data collection.***
- ***Describe and demonstrate aseptic techniques for handling, culturing, and analyzing bacteria colonies.***
- ***Conduct gel electrophoresis to separate DNA fragments.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on disease prevention and treatment.***
- ***Describe the unique solutions to the health and medical problems of this century.***
- ***Describe the global impact of biomedical science solutions.***

- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:
21.75 days



Problem [7]: [Forensic Autopsy]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**
Missouri Learning Standards*(NGSS)* ● ***ETS1.1*** ● ***ETS1.2*** ● ***ETS1.3***	***In this problem students will work as medical experts to work through mysterious death cases. First, as forensic pathologists, students will examine a fetal pig using the same protocol as a human autopsy. Second, students will draw on information they have learned in the previous courses about human body systems to design a fictional death case. Students will showcase the clues left behind in***

	the body and tell the story of how the person died through medical documents, including an autopsy report and medical history forms. Students will finally be tasked with solving another group's proposed case.	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? ● ***Collect and analyze data to draw a conclusion.*** ● ***Solve a problem using analytical and critical thinking skills.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Analyze health and disease data to inform public health decisions.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.***	*What are essential Questions?* 1. Why are size measurements and weights of organs recorded during an autopsy? 2. What clues left behind in the body tell the story of how a person died?

	● ***Create an effective team environment to promote successful goal attainment.***	

Learning Targets

Students will…

- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Describe and identify cell and tissue features using a microscope.***
- ***Analyze medical evidence to diagnose a patient's health condition.***
- ***Identify and describe careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities of biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***

• ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***
Unit Duration:
21.75 days



Problem [8]: [Independent Project]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**	
Missouri Learning Standards*(NGSS)* • ***ETS1.1*** • ***ETS1.2*** • ***ETS1.3***	***In this problem students will work independently to determine an area of interest in the biomedical sciences and work on a long-term open-ended problem. Students will use skills learned in the previous courses as well as the previous problems to help them complete their project. Student work will include completing a literature review, writing and carrying out the methodology for their project, analyzing the results, making adjustments as needed, and finally presenting the results of their work to an adult audience. Students may work with mentors or advisors from a university, hospital, physician's office, or industry partner to help guide them as they complete their work.***	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? • ***Design an experiment that investigates a research question.*** • ***Collect and analyze data to draw a conclusion.*** • ***Solve a problem using analytical and critical thinking skills.***	*What are essential Questions?* 1. What should a scientist or medical professional consider before designing and running a biomedical science investigation? 2. How might a visual model, such as a Gantt chart, assist in project management?

	● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain why scientists must have the courage to take a calculated risk.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Demonstrate awareness of the education and skills required for biomedical science professionals.*** ● ***Use project management to successfully and efficiently complete tasks as scheduled.*** ● ***Apply professional standards, as they apply to the habits and characteristics of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	3. Why is it important to document all work when completing a project?

Learning Targets

Students will…

- ***Collaborate with a mentor who is an expert in their field.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Devise and execute a plan to solve a problem.***
- ***Explain the importance of collecting data from multiple sources for a problem.***

- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how iterative processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Evaluate the reliability and credibility of sources when gathering information.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Explain how creativity can lead to scientific discovery.***
- ***Select appropriate technology and software for data collection.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Write a proposal for an independent project.***
- ***Establish a protocol, timeline, and a means to measure progress toward completion of a project.***
- ***Produce a Gantt chart to manage the work of a project.***
- ***Research and compile information about a chosen topic.***
- ***Explain how breaking a large project into many smaller tasks allows modifications to be made as necessary and serves as a means to monitor progress toward completion of the project.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Demonstrate the importance of punctuality and meeting deadlines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:

Course Name: PLTW-Biomedical Innovations (Yr. 4)

All Year



Assessment Evidence

Rubric/Scoring	**Assessment**
[I.e., RUBRICS, STANDARDS OF PERFORMANCE, REQUIRED LEVEL OF ACHIEVEMENT FOR MASTERY] Performance Task Review Criteria	What is assessment? *[i.e., PERFORMANCE TASK(S), PRE-TESTS, POST-TESTS, OTHER EVIDENCE]* (Pre-assessment can double as the post-assessment) ● Use summative assessments to frame meaningful performance goals. ● Show criteria and models in advance. ● Assess before teaching. ● Offer appropriate choices. ● Provide feedback early and often. ● Encourage self-assessment and goal setting ● Allow new evidence of achievement to replace old evidence.

Course Name: PLTW-Biomedical Innovations (Yr. 4)

Course Name: PLTW-Biomedical Innovations (Yr. 4)

Learning Plan



Week(s)	Topic	Resources/Texts	Learning Targets	Assessment

Standard 1: *LS2.7*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to

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			increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 2: *LS4.6*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which

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			bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 3: *ESS3.1*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to

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			increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 4: *ESS3.4*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which

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			bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 5: *ETS1.1*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*** **The student exhibits no major errors or omissions.**		● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects

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			could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 6: *ETS1.2*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*** **The student exhibits no major errors or omissions.**		● Students will design an emergency department that takes efficient patient care to the next level. ● Students will investigate the various ways in which data can be manipulated, explore what to look for when evaluating

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		data presented by others, critique scientific data presented in popular media, and compare such data with scientific data presented in scientific journals. ● Students will investigate the evolution of various biomedical products, brainstorm ideas for a new biomedical product or for a way to improve an existing product, and evaluate solutions of the past and present. ● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. ● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an

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			autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 7: *ETS1.3*		
Topic: Problem 1-8		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**

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		● Students will design an emergency department that takes efficient patient care to the next level. ● Students will investigate the various ways in which data can be manipulated, explore what to look for when evaluating ● data presented by others, critique scientific data presented in popular media, and compare such data with scientific data presented in scientific journals. ● Students will investigate the evolution of various biomedical products, brainstorm ideas for a new biomedical product or for a way to improve an existing product, and evaluate solutions of the past and present. ● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. ● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation

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			through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 1: *LS2.7*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to

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			increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 2: *LS4.6*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which

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			bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 3: *ESS3.1*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to

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			increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 4: *ESS3.4*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** **The student exhibits no major errors or omissions.**		● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. Students will then isolate DNA from three different bacterial cultures and perform PCR in order to detect which

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			bacterial strain present in the water is making the family sick. ● Students will study the relationship between exposure and illness using a case study involving lead poisoning. They will design an experiment to test the effects of a particular chemical and doses of that chemical on plant growth. They will use their results to produce a dose-response curve and relate this graph to the overall effect of the selected chemical. ● Students will use their compiled information to design an action plan to increase awareness, monitor resources or individuals in the community, improve conditions, and ensure a clean and safe environment.
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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Standard 5: *ETS1.1*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*** **The student exhibits no major errors or omissions.**		● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects

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			could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
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	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 6: *ETS1.2*			
Topic: Problem 1-8			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*** **The student exhibits no major errors or omissions.**		● Students will design an emergency department that takes efficient patient care to the next level. ● Students will investigate the various ways in which data can be manipulated, explore what to look for when evaluating

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		data presented by others, critique scientific data presented in popular media, and compare such data with scientific data presented in scientific journals. ● Students will investigate the evolution of various biomedical products, brainstorm ideas for a new biomedical product or for a way to improve an existing product, and evaluate solutions of the past and present. ● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. ● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an

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			autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
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Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 7: *ETS1.3*		
Topic: Problem 1-8		
Grade: 11-12		
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**	**Sample Activities**

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		● Students will design an emergency department that takes efficient patient care to the next level. ● Students will investigate the various ways in which data can be manipulated, explore what to look for when evaluating ● data presented by others, critique scientific data presented in popular media, and compare such data with scientific data presented in scientific journals. ● Students will investigate the evolution of various biomedical products, brainstorm ideas for a new biomedical product or for a way to improve an existing product, and evaluate solutions of the past and present. ● Students will test a local water sample as well as simulated well water from the case for the presence of coliforms and E. coli. ● Students will play the role of epidemiologists, dedicated medical professionals at the heart of the public health field, as they monitor the health of populations and search for patterns in disease. ● Students will complete projects that allow them to assemble a recombinant plasmid as they ligate, or link, DNA from two different sources. Students will then analyze the results of this ligation

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			through both transformation and restriction analysis. ● Students will then create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing. ● Students will be challenged to apply the skills and knowledge they have learned throughout their biomedical science coursework, especially their time and project management skills. Projects could include a series of experiments to answer a question, planning a community event related to biomedical science, prototyping a medical or healthcare device, drawing blueprints for a new hospital or doctor's office design, or completing an internship.
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*** **The student exhibits no major errors or omissions.**		
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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[PLTW-Medical Interventions (Yr. 3)] ***Course Overview***	
Grade level(s): 11-12	**Credits earned:** 0.5 credits of weighted high school science credit per semester with the potential to earn college credit through Missouri S&T if certain criteria are met.
Course Rationale	**Course Description**
Medical Interventions (MI) allows students to investigate the variety of interventions involved in the prevention, diagnosis, and treatment of disease as they follow the lives of a fictitious family. A "How-To" manual for maintaining overall health and homeostasis in the body, the course will explore how to prevent and fight infection, how to screen and evaluate the code in our DNA, how to prevent, diagnose, and treat cancer, and how to prevail when the organs of the body begin to fail. Through these scenarios students will be exposed to the wide range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics. Each family case scenario will introduce multiple types of interventions, reinforce concepts learned in the previous two courses, and present new content. Interventions may range from simple diagnostic tests to treatment of complex diseases and disorders. These interventions will be showcased across the generations of the family and will provide a look at the past, present, and future of biomedical science. Lifestyle choices and preventive measures are emphasized throughout the course as well as the important role that scientific thinking and	In PLTW Medical Interventions (MI), students follow the life of a fictitious family as they investigate how to prevent, diagnose, and treat disease. Students explore how to detect and fight infection; screen and evaluate the code in human DNA; evaluate cancer treatment options; and prevail when the organs of the body begin to fail. Through real-world cases, students are exposed to a range of interventions related to immunology, surgery, genetics, pharmacology, medical devices, and diagnostics.

engineering design play in the development of interventions of the future.	

Transfer Goals/Big Ideas

What are transfer Goals/ Big Ideas?

- Asking Questions and Defining Problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in an argument from evidence
- Obtaining, evaluating, and communication information

Priority Missouri Learning Standards/National Standards

Missouri Learning Standards***(NGSS)***

- ***PS2.6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.***
- ***LS1.1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.***
- ***LS1.2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.***
- ***LS3.1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.***
- ***LS3.2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.***

- ***ETS1.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.***
- ***ETS1.3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.***

Course Name: PLTW-Medical Interventions (Yr. 3)

<table>
<tr><td colspan="3">Unit [1]: [How to Fight an Infection]
Desired Results</td></tr>
<tr><td>Standards</td><td colspan="2">Transfer Goal(s) /Big Ideas</td></tr>
<tr><td rowspan="2">[ID by label, standards addressed in this unit] - Use Letters and Numbers (do not write out whole standard)

Missouri Learning Standards(NGSS)
● PS2.6
● LS1.1
● LS1.2
● LS3.1
● LS3.2
● ETS1.2
● ETS1.3</td><td colspan="2">In this unit, you explore interventions involved in detecting, fighting, and preventing an infectious disease as you investigate a potential outbreak at a fictitious college. You look at the aftermath of the disease as you explore how to diagnose and manage hearing loss. Finally, you discuss infectious disease prevention, specifically through vaccination. You investigate the impact vaccination has had on public health over the years and interpret how vaccines have altered disease trends.</td></tr>
<tr><td>Enduring Understandings</td><td>Essential Questions</td></tr>
<tr><td>What are enduring understandings?
● Design an experiment that investigates a research question.
● Collect and analyze data to draw conclusions.
● Solve a problem using analytical and critical thinking.
● Explain the value of diverse perspectives in the problem-solving process.
● Explain how scientists use calculated risks to increase scientific knowledge.</td><td>What are essential Questions?
1. What are medical interventions?
2. What evidence helps scientists determine the source of a potential outbreak of an infectious disease?
3. What factors speed up or slow down the spread of disease through a population?
4. How has advanced technology, such as bioinformatics, changed disease detection?
5. Why are certain classes of antibiotics prescribed to treat specific bacterial infections?</td></tr>
</table>

	● ***Collect and analyze medical information to evaluate the cause, prevention, and treatment of disease.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Explain the structure and function of bacterial cells and how antibiotics work to disrupt their growth.*** ● ***Explain the physiological processes associated with disease or injury.*** ● ***Describe how diagnostic tests are used to assess the health of an individual and/or indicate the presence of disease.*** ● ***Evaluate ethical and moral issues related to various medical interventions.*** ● ***Describe how diagnostic tests are used to assess the health of an individual and/or indicate the presence of disease.*** ● ***Describe the applications of bioinformatics in health and wellness.*** ● ***Explain the education and skills required for biomedical science professionals.*** ● ***Describe how medical interventions are used to improve health or alter the course of an illness.*** ● ***Explain how recombinant DNA technology allows scientists to custom-designed bacteria that can***	6. Why can bacterial cells transfer genes from one bacterial cell to another and why is this important? 7. How has the development of antibiotics impacted human health? 8. What actions are humans taking that are contributing to bacteria becoming resistant to commonly used antibiotics? 9. How does dysfunction in human anatomy relate to different types of hearing loss? 10. How is hearing loss diagnosed? 11. How is the type of hearing loss related to options for treatment? 12. What are the bioethical concerns related to the use of cochlear implant technology? 13. How do vaccines aid the immune system in fighting off infection? 14. How has vaccination impacted disease trends locally and globally? 15. Why are plasmids important tools in genetic engineering? 16. What role do epidemiologists play in the detection, prevention, and treatment of both chronic and infectious disease?

	produce a variety of important protein products. ● ***Describe the societal impact of biomedical science professionals.*** ● ***Apply professional standards, as they relate to the personal traits of a biomedical science professional.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	

Learning Targets

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.***
- ***Identify and explain the purpose and importance of experimental controls.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, and when appropriate, redesign and repeat the experiment.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Obtain and process credible information from various sources.***

- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Select and use appropriate technology (probes and sensors) and software to collect and analyze physiological data.***
- ***Describe and apply aseptic techniques for handling and culturing microbial samples.***
- ***Analyze connections between patients in an outbreak situation, determine appropriate tests to identify the pathogen, and determine the steps for treatment and containment.***
- ***Interpret concentration results of a quantitative antigen-based assay for various patients to infer a path of infection.***
- ***Analyze patient symptoms and medical evidence to diagnose a fictional patient.***
- ***Describe the various laboratory methods that are used to manufacture vaccines.***
- ***Explain the impact vaccines have had on disease occurrence.***
- ***Analyze disease data, design epidemiologic studies, and evaluate prevention and therapy for chronic and infectious diseases.***
- ***Describe the function of the major structures in the bacterial cell and how these structures provide the cell defense.***
- ***Explain how the four main classes of antibiotics target specific bacterial structures and biological pathways.***
- ***Compare the three types of bacterial gene transfer and the relationship of this transfer to antibiotic resistance.***
- ***Describe the ways in which the misuse of antibiotics can impact bacterial growth.***
- ***Explain the principles of the Enzyme-linked Immunosorbent Assay (ELISA) test and interpret ELISA results to detect the presence and concentration of a pathogen.***
- ***Determine the appropriate hearing tests to diagnose sensorineural and conductive hearing loss.***
- ***Interpret audiograms to identify different types of hearing loss and select appropriate interventions.***
- ***Relate the structure of the ear to function and explain the pathophysiology of hearing loss.***
- ***Describe how vaccinations protect against illness.***
- ***Describe how computer database technology can be used to analyze genetic information.***
- ***Use computer database technology to analyze genetic information and interpret the results.***
- ***Explain how molecular tools, such as ligase and restriction enzymes, are used to cut and paste DNA from different sources.***
- ***Identify which restriction enzyme to use for a given situation.***
- ***Describe how recombinant DNA technology can be used to produce vaccines.***
- ***Insert plasmid DNA into bacterial cells in the laboratory and observe how this genetic information relates to new traits of the bacteria.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on society, including disease diagnosis, prevention, and treatment.***

- ***Describe the global impact of biomedical science solutions.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Describe the bioethical concerns and considerations related to the use of cochlear implant technology.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:
45 days

Unit [2]: [How to Screen What is in Your Genes]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**
Missouri Learning Standards*(NGSS)* • ***PS2.6*** • ***LS1.1*** • ***LS1.2*** • ***LS3.1*** • ***LS3.2*** • ***ETS1.2***	***Today scientists and biomedical professionals have the power to look inside our cells and decipher the DNA code. In this unit, you examine how the study of genetics alters the way doctors and scientists treat disease, as well as the way humans reproduce. You research types of genetic testing and screening available to potential parents and discuss ethical implications of these tests. You also examine available reproductive technology and debate and discuss medical interventions of the future.***

	Enduring Understandings	Essential Questions
● ***ETS1.3***	*What are enduring understandings?* ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw conclusions.*** ● ***Solve a problem using analytical and critical thinking.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain how scientists use calculated risks to increase scientific knowledge.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Collect and analyze medical information to evaluate the cause, prevention, and treatment of disease.*** ● ***Describe how medical interventions are used to improve health or alter the course of an illness.*** ● ***Explain how recombinant DNA technology allows scientists to custom-designed bacteria that can produce a variety of important protein products.*** ● ***Explain how single base pair changes, called single nucleotide polymorphisms***	*What are essential Questions?* 1. How do genetic counselors assist patients with decisions related to reproduction or personal disease risk? 2. What is the relationship between phenotype and genotype? 3. What medical interventions and lifestyle modifications can help a pregnant woman have a healthy pregnancy? 4. What are the ethical implications of genetic testing? 5. How can genetic diseases be cured if scientists replace faulty genes? 6. How might gene therapy open the door to genetic enhancement? 7. What are some of the ethical dilemmas surrounding current and future reproductive technology?

	(SNPs), can be identified through genetic testing and often correlate to specific diseases or traits. ● ***Describe how genetic counseling can help a family understand the risks of having a child with a genetic disorder, as well as inheritance information about an already diagnosed condition.*** ● ***Explain the education and skills required for biomedical science professionals.*** ● ***Describe the societal impact of biomedical science professionals.*** ● ***Apply professional standards, as they relate to the personal traits of a biomedical science professional.*** ● ***Evaluate ethical and moral issues related to various medical interventions.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	

Learning Targets

Students will…

- ***Identify and explain the purpose and importance of experimental controls.***
- ***Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***

- ***Identify possible sources of errors, and when appropriate, redesign and repeat the experiment.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Obtain and process credible information from various sources.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how different processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Conduct both horizontal (DNA) and vertical (protein) gel electrophoresis.***
- ***Explain the applications of PCR technology as well as the role of each reagent in the process.***
- ***Analyze patient symptoms and medical evidence to diagnose a fictional patient.***
- ***Explain how reproductive technology works.***
- ***Evaluate the promise and limitations of gene editing.***
- ***Identify which restriction enzyme to use for a given situation.***
- ***Identify single base- pair differences in DNA through laboratory techniques, such as DNA extraction, PCR, and restriction analysis.***
- ***Interpret karyotype results and determine outcomes and options.***
- ***Analyze personal and family medical history and genetic testing results to make a recommendation for a particular genetic counseling case.***
- ***Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities for biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on society, including disease diagnosis, prevention, and treatment.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Describe the importance of privacy for all individuals.***

- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Defend an argument governing future gene editing research.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:
23 days

Unit [3]: [How to Conquer Cancer]
Desired Results

Standards	**Transfer Goal(s) /Big Ideas**
Missouri Learning Standards*(NGSS)* ● ***PS2.6*** ● ***LS1.1*** ● ***LS1.2*** ● ***LS3.1*** ● ***LS3.2*** ● ***ETS1.2*** ● ***ETS1.3***	***In this unit, you are introduced to Mike Smith, the 16-year-old son in the Smith family. Through investigation of Mike's case, you explore techniques used to diagnose cancer, including diagnostic imaging and examination of cancerous tissue. You look at the physiology of cancer and investigate the genes involved with cancer. Investigating risk factors associated with cancer, you design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light, using UV sensitive yeast cells. You perform marker analysis on mock DNA samples to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. Throughout the unit, you look at lifestyle choices that can reduce the chances that a person***

will develop particular types of cancer.Finally you follow Mike as he progresses through his treatment. You learn about the treatments available for cancer patients as well as the therapies available to help patients cope with the pain associated with treatment. You explore the future of cancer treatment as you review clinical trials and pharmaceutical innovation.

Enduring Understandings	Essential Questions
What are enduring understandings? ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw conclusions.*** ● ***Solve a problem using analytical and critical thinking.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain how scientists use calculated risks to increase scientific knowledge.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Collect and analyze medical information to evaluate the cause, prevention, and treatment of disease.*** ● ***Describe how diagnostic tests are used to assess the health of an individual and/or indicate the presence of disease.***	*What are essential Questions?* 1. How does the development of cancer relate to the cell cycle? 2. How do factors such as age, personal lifestyle choices, or environment influence a person's risk for developing cancer? 3. How has imaging technology changed medicine? 4. What information can gene expression patterns tell scientists? 5. How can behavioral, biological, environmental, and genetic risk factors increase or decrease the chance that a person will develop cancer? 6. How can molecular tests be used to detect inherited genetic mutations associated with certain cancers? 7. What are the advantages and disadvantages of knowing your genetic predisposition to specific cancers? 8. Why are routine cancer screenings important?

	● ***Explain the physiological processes associated with disease or injury.*** ● ***Describe how medical interventions are used to improve health or alter the course of an illness.*** ● ***Describe the applications of bioinformatics in health and wellness.*** ● ***Explain how single base pair changes, called single nucleotide polymorphisms (SNPs), can be identified through genetic testing and often correlate to specific diseases or traits.*** ● ***Explain the education and skills required for biomedical science professionals.*** ● ***Describe the societal impact of biomedical science professionals.*** ● ***Apply professional standards, as they relate to the personal traits of a biomedical science professional.*** ● ***Evaluate ethical and moral issues related to various medical interventions.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	9. How do medical professionals design the most appropriate treatment plan for a cancer patient? 10. Why might a cancer patient choose not to undergo chemotherapy or radiation? 11. How is biofeedback therapy used to help patients improve their health or manage pain? 12. How do advances in technology allow for the development of artificial limbs that look and move like actual human limbs? 13. How do physical and occupational therapists help patients with disabilities or patients recovering from surgery or injury? 14. How can information in our genes affect how our bodies interact with certain medications? 15. How are clinical trials set up to ensure all data collected is valid and that all human subjects are treated ethically? 16. How might nanomedicine change the prevention, diagnosis, and treatment of disease?
Learning Targets		

Course Name: PLTW-Medical Interventions (Yr. 3)

Students will…

- ***Develop an experimental protocol that includes a testable hypothesis.***
- ***Distinguish between the independent and dependent variables.***
- ***Identify and explain the purpose and importance of experimental controls.***
- ***Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, and when appropriate, redesign and repeat the experiment.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***
- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations.***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Obtain and process credible information from various sources.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how different processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Analyze cell and tissue samples using appropriate microscopy skills.***
- ***Select and use appropriate technology (probes and sensors) and software to collect and analyze physiological data.***
- ***Explain how DNA microarrays are used to compare gene expression (mRNA expression) between different tissue samples or sample groups.***
- ***Describe how microarray data can be used to evaluate cancer risks.***
- ***Demonstrate proper usage of a microscope.***
- ***Explain why controlled, randomized, double-blind studies are considered the gold standard for clinical trials. KS4.1.5***
- ***Analyze patient symptoms and medical evidence to diagnose a fictional patient.***
- ***Analyze disease data, design epidemiologic studies, and evaluate prevention and therapy for chronic and infectious diseases.***
- ***Analyze the difference between normal cells and cancer cells.***

- ***Describe the different uses for X-rays, bone scans, CT scans, and MRIs, as well as how each technology works.***
- ***Connect cell cycle regulatory gene mutations to the development of cancer.***
- ***Describe the behavioral, biological, environmental, and genetic risk factors that can increase the chance that a person will develop cancer.***
- ***Evaluate genetic risk factors for cancer using family history and marker analysis.***
- ***Evaluate the benefits and side effects of cancer treatments.***
- ***Describe how myoelectric prosthetic limbs work to restore function to patients who have lost a limb.***
- ***Differentiate between physical and occupational therapy.***
- ***Explain how biofeedback therapy can improve health and/or manage pain.***
- ***Describe how computer database technology can be used to analyze genetic information.***
- ***Use computer database technology to analyze genetic information and interpret the results.***
- ***Identify single base- pair differences in DNA through laboratory techniques, such as DNA extraction, PCR, and restriction analysis.***
- ***Predict how a person will respond to particular medications based on the patient SNP profile.***
- ***Explain how SNPs can be identified through genetic testing and how they correlate to specific diseases or traits.***
- ***Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities for biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***
- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on society, including disease diagnosis, prevention, and treatment.***
- ***Describe the global impact of biomedical science solutions.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Describe the importance of privacy for all individuals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Explain why clinical trials are regulated by strict guidelines.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***

● ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.*** ● ***Employ a peer review process to give effective and constructive feedback to meet given outcomes.***
Unit Duration:
58 days

Unit [4]: [How to Prevail When Organs Fail]
Desired Results

Standards	Transfer Goal(s) /Big Ideas
Missouri Learning Standards*(NGSS)* ● ***PS2.6*** ● ***LS1.1*** ● ***LS1.2*** ● ***LS3.1*** ● ***LS3.2*** ● ***ETS1.2*** ● ***ETS1.3***	***In this unit, you review the science of diabetes and the relationship between glucose and insulin. You also explore the past, present, and future of insulin production. You learn how to produce and purify a protein in a laboratory setting to understand how human insulin is produced to treat diabetics. You work in teams to solve a medical mystery. You investigate the patient's symptoms, suggest further diagnostic tests, and use information you find to piece together a diagnosis and suggest the best treatment option.Acting as part of a surgical team, you follow the patient as they go through the process of organ transplantation. You learn about organ allocation policies and determine donor compatibility through both blood and tissue typing. You practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. Throughout the course, you have been introduced to various medical interventions as you followed the Smith family. You have seen how medicine has changed throughout history and have investigated how medicine might change in the future. In this final unit, you think about how science is changing the ability of people to survive in the face of illness and injury and you use what you learned throughout the course to design your own version of a "superhuman." Finally, as you review the Smith***

	family tree, you reflect on the role medical interventions play in preventing, diagnosing, and treating disease and reflect on your own career aspirations.	
	Enduring Understandings	**Essential Questions**
	What are enduring understandings? ● ***Design an experiment that investigates a research question.*** ● ***Collect and analyze data to draw conclusions.*** ● ***Solve a problem using analytical and critical thinking.*** ● ***Explain the value of diverse perspectives in the problem-solving process.*** ● ***Explain how scientists use calculated risks to increase scientific knowledge.*** ● ***Select and use appropriate tools, technology, and/or software for experimental and clinical data collection and analysis.*** ● ***Collect and analyze medical information to evaluate the cause, prevention, and treatment of disease.*** ● ***Explain the structure and function of bacterial cells and how antibiotics work to disrupt their growth.*** ● ***Explain the physiological processes associated with disease or injury.***	*What are essential Questions?* 1. How has the diagnosis and treatment for diabetes changed in the last 200 years? 2. How can genetic engineering be used to produce proteins such as insulin? 3. How does the sequence of amino acids relate to the overall shape of a protein? 4. What techniques can be used to separate proteins in a mixture? 5. How does kidney failure impact homeostasis in the human body? 6. How does dialysis replicate kidney function? 7. How is it decided who should receive a donated organ? 8. What are the factors that determine whether a donor and a recipient are a compatible match? 9. What are the pros and cons of minimally invasive surgery over traditional open procedures? 10. What determines whether an organ or tissue in the body can be replaced?

	● ***Describe how medical interventions are used to improve health or alter the course of an illness.*** ● ***Explain how recombinant DNA technology allows scientists to custom-design bacteria that can produce a variety of important protein products.*** ● ***Explain the education and skills required for biomedical science professionals.*** ● ***Describe the societal impact of biomedical science professionals.*** ● ***Apply professional standards, as they relate to the personal traits of a biomedical science professional.*** ● ***Evaluate ethical and moral issues related to various medical interventions.*** ● ***Communicate effectively with a specific audience.*** ● ***Create an effective team environment to promote successful goal attainment.***	11. What are the benefits and risks of using xenotransplantation and tissue engineering for replacement organs? 12. What are the ethical considerations for xenotransplantation and tissue engineering? 13. How can technology help remodel or enhance the human body? 14. What role do medical interventions play in the prevention, diagnosis, and treatment of disease?

Learning Targets

Students will…

- ***Identify and explain the purpose and importance of experimental controls.***
- ***Maintain a detailed repeatable account of an experiment in a physical or digital laboratory notebook.***
- ***Conduct background research using credible sources.***
- ***Select and use appropriate equipment to conduct experiments.***
- ***Identify possible sources of errors, and when appropriate, redesign and repeat the experiment.***
- ***Communicate the findings of an experiment in oral and written (including digital) form.***

- ***Describe why experimental design is a continual process.***
- ***Read and follow established protocols and instructions.***
- ***Display data appropriately and accurately in multiple formats (graphs, tables, diagrams).***
- ***Perform necessary data calculations***
- ***Draw logical conclusions from experimental data.***
- ***Devise and execute a plan to solve a problem.***
- ***Obtain and process credible information from various sources.***
- ***Describe how persistence is a key mindset when identifying problems and/or pursuing solutions.***
- ***Outline how different processes inform biomedical science decisions, improve solutions, and inspire new ideas.***
- ***Explain how solutions for complex problems can require interdisciplinary collaboration to incorporate a wide range of perspectives and skills.***
- ***Explain the importance of risk taking in performing experiments and developing solutions.***
- ***Identify the pros and cons associated with decisions made in biomedical science.***
- ***Describe how failure, or unexpected results, can produce positive outcomes by improving understanding.***
- ***Conduct both horizontal (DNA) and vertical (protein) gel electrophoresis.***
- ***Describe and apply aseptic techniques for handling and culturing microbial samples.***
- ***Describe the skill, dexterity, and eye-hand coordination necessary to complete surgical techniques.***
- ***Match an organ donor with a compatible recipient based on blood typing and HLA typing results.***
- ***Analyze patient symptoms and medical evidence to diagnose a fictional patient.***
- ***Analyze disease data, design epidemiologic studies, and evaluate prevention and therapy for chronic and infectious diseases.***
- ***Compare the three types of bacterial gene transfer and the relationship of this transfer to antibiotic resistance.***
- ***Identify symptoms of End Stage Renal Disease (ESRD).***
- ***Analyze the pros and cons of hemodialysis, peritoneal dialysis, and kidney transplant for a patient with ESRD.***
- ***Explain how molecular tools, such as ligase and restriction enzymes, are used to cut and paste DNA from different sources.***
- ***Outline the steps required to produce a protein in the laboratory.***
- ***Insert plasmid DNA into bacterial cells in the laboratory and observe how this genetic information relates to new traits of the bacteria.***
- ***Isolate a protein based on its properties using column chromatography.***
- ***Verify an isolated protein using protein electrophoresis.***
- ***Identify and describe the different careers of professionals who research, diagnose, and treat medical conditions.***
- ***Describe the education requirements, salary ranges, professional licensure, skills, and responsibilities for biomedical science professionals.***
- ***Explain the importance of life-long learning for biomedical science professionals.***

- ***Apply professional standards, as they relate to the habits and characteristics of a biomedical science professional.***
- ***Describe the impact that biomedical science research and interventions have on society, including disease diagnosis, prevention, and treatment.***
- ***Demonstrate the importance of honesty, integrity, and accountability for biomedical professionals.***
- ***Describe the importance of privacy for all individuals.***
- ***Create and support an environment that fosters teamwork, emphasizes quality, and promotes learning.***
- ***Describe the importance of ethical considerations when making biomedical science decisions.***
- ***Use Federal policy guidelines to defend who should receive a donated organ in a given situation.***
- ***Defend arguments as to whether or not further research for xenotransplantation and tissue engineering should be banned.***
- ***Follow acceptable formats for writing assignments and professional presentations.***
- ***Modify communications to meet the needs of the audience and be appropriate to the situation.***
- ***Properly cite references for all reports in an accepted format.***
- ***Use proper elements of written communication (spelling, grammar, and formatting).***
- ***Respect others' viewpoints.***
- ***Describe the importance of each team member's contribution to the project.***
- ***Identify basic conflict resolution strategies and employ those strategies as necessary and appropriate.***

Unit Duration:
49 days



Assessment Evidence

Rubric/Scoring	**Assessment**

Course Name: PLTW-Medical Interventions (Yr. 3)

[I.e., RUBRICS, STANDARDS OF PERFORMANCE, REQUIRED LEVEL OF ACHIEVEMENT FOR MASTERY] Performance Task Review Criteria	What is assessment? *[i.e., PERFORMANCE TASK(S), PRE-TESTS, POST-TESTS, OTHER EVIDENCE]* (Pre-assessment can double as the post-assessment) ● Use summative assessments to frame meaningful performance goals. ● Show criteria and models in advance. ● Assess before teaching. ● Offer appropriate choices. ● Provide feedback early and often. ● Encourage self-assessment and goal setting ● Allow new evidence of achievement to replace old evidence.

Course Name: PLTW-Medical Interventions (Yr. 3)

Learning Plan



Week(s)	Topic	Resources/Texts	Learning Targets	Assessment

Standard 1: PS2.6			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		**Sample Activities**
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding

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		audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. ● Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. ● Students will examine the technology that is being used to give researchers a better understanding of the differences

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		in gene expression in both cancer cells and normal cells. ● Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. ● Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to

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		separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. ● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the

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			perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 2: LS1.1			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding

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		audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. ● Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. ● Students will examine the technology that is being used to give researchers a better understanding of the differences

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		in gene expression in both cancer cells and normal cells. ● Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. ● Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to

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		separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. ● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the

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			perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
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Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 3: LS1.2			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding

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		● audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. ● Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. ● Students will examine the technology that is being used to give researchers a better understanding of the differences

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		in gene expression in both cancer cells and normal cells. ● Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. ● Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to

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		separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. ● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the

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			perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

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Standard 4: LS3.1			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding

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		● audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. ● Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. ● Students will examine the technology that is being used to give researchers a better understanding of the differences

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		● in gene expression in both cancer cells and normal cells. ● Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. ● Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to

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			perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
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Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
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Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 5: PS2.6			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	

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Score 3.0	**The student:** ● ***Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.*** **The student exhibits no major errors or omissions.**	● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding ● audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune

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		system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine. ● Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. ● Students will examine the technology that is being used to give researchers a better understanding of the differences ● in gene expression in both cancer cells and normal cells. ● Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order

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		to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. ● Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy.

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			● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:**		

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	However, the student exhibits major errors or omissions regarding the more complex ideas and processes.		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
Score 0.0	**Even with help, no understanding or skill demonstrated.**		

Standard 6: ETS1.2			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and

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		their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria. ● Students will learn how to interpret audiograms and match up their patient case study with the corresponding ● audiogram. Students will then use what they have learned to make a recommendation as to what intervention is the most appropriate for the patient case study. ● Students will review how vaccines work in the body and relate this mechanism to the workings of the human immune system. Students will explore the techniques scientists use to produce vaccines. They will delve deeper into the science of recombinant DNA technology and learn how genetic engineering can be used to manufacture viable vaccines. Students will engineer a paper plasmid to produce a viral protein that can be used as a vaccine.

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		• Students will learn about gene therapy, debate its safety, and write a policy statement highlighting guidelines and restrictions on gene therapy testing and research. Students will examine available reproductive technology and debate and discuss medical interventions of the future. • Students will examine the technology that is being used to give researchers a better understanding of the differences • in gene expression in both cancer cells and normal cells. • Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. • Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this

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		scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. ● Students will use the process of bacterial transformation to insert a plasmid containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. ● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice

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			laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue engineering. Students will investigate how these technologies work and then construct an argument from the perspective of different stakeholders arguing over whether or not further research for these interventions should be banned.
	2.5	No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content.	
Score 2.0	**There are no major errors or omissions regarding the simpler details and processes as the student:** **However, the student exhibits major errors or omissions regarding the more complex ideas and processes.**		
	1.5	Partial knowledge of the 2.0 content, but major errors or omissions regarding the 3.0 content.	
Score 1.0	**With help, a partial understanding of some of the simpler details and processes and some of the more complex ideas and processes.**		
	0.5	With help, a partial understanding of the 2.0 content, but not the 3.0 content.	
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Standard 7: ETS1.3			
Topic: Units 1-4			
Grade: 11-12			
Score 4.0	**In addition to Score 3.0, in-depth inferences and applications that go beyond what was taught.**		
	3.5	In addition to score 3.0 performance, in-depth inferences and applications with partial success.	
Score 3.0	**The student:** ● ***Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.*** **The student exhibits no major errors or omissions.**		● Students will work on interventions involved in detecting, fighting, and preventing an infectious disease as they investigate a potential outbreak at a fictitious college. ● Students will review bacterial structure and investigate the mechanisms by which DNA from one bacterial cell is transferred to another. Students then explore various types of antibiotics and their mode of action against the bacteria they target. ● Students will look at the propagation of antibiotic resistant bacteria and how the misuse of antibiotics plays a role in the development of antibiotic resistant bacteria.

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		• Students will examine the technology that is being used to give researchers a better understanding of the differences • in gene expression in both cancer cells and normal cells. • Students will design and perform an experiment to test the effectiveness of various sunscreens or types of cloth against UV light as they attempt to protect UV-sensitive yeast cells. They will analyze marker analysis results in order to diagnose a BRCA2 gene mutation associated with breast cancer, play the role of a virologist working with viruses associated with cancer, and create a timeline of routine cancer screenings we must complete in our lifetime. • Students learn that Mike will have to have his arm amputated to prevent further tumor growth. Through this scenario students will study prosthetic limb technologies, design and build a model prosthetic arm, and explore the role physical and occupational therapists play in a patient's rehabilitation following amputation surgery. • Students will use the process of bacterial transformation to insert a plasmid

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		containing the gene for green fluorescent protein (GFP) into E. coli cells. Students will then use chromatography to separate the GFP protein from the other proteins in the bacterial cells. They will collect proteins in differential fractions and analyze the contents of these fractions using gel electrophoresis. Students will relate their molecular work to the case of Diana Jones, who is a Type 1 diabetic on insulin therapy. ● Students will learn about organ allocation policies by deciding which of two matching patients should receive a donated kidney. Students then learn that members of Diana's family have offered to be potential living donors and must determine who should donate their kidney to Diana based on blood type and tissue type. Students will then practice laparoscopic and general surgery techniques and investigate the members of the transplant team involved along the transplant path. ● Students will investigate some of the technologies researchers are exploring as they strive to replace damaged organs, including xenotransplantation and tissue

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6-12 Science Grade-Level Expectations

Missouri Department of Elementary and Secondary Education
Spring 2016

The Department of Elementary and Secondary Education does not discriminate on the basis of race, color, religion, gender, gender identity, sexual orientation, national origin, age, veteran status, mental or physical disability, or any other basis prohibited by statute in its programs and activities. Inquiries related to department programs and to the location of services, activities, and facilities that are accessible by persons with disabilities may be directed to the Jefferson State Office Building, Director of Civil Rights Compliance and MOA Coordinator (Title VI/Title VII/Title IX/504/ADA/ADAAA/Age Act/GINA/USDA Title VI), 5th Floor, 205 Jefferson Street, P.O. Box 480, Jefferson City, MO 65102-0480; telephone number 573-526-4757 or TTY 800-735-2966; email civilrights@dese.mo.gov

PS1 - Matter and Its Interactions		
Concept	**Middle School**	**High School**
A	6-8.PS1.A.1 Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms. 6-8.PS1.A.2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.] 6-8.PS1.A.3 Gather, analyze, and present information to describe that synthetic materials come from natural resources and how they impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] 6-8.PS1.A.4 Develop a model that describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]	9-12.PS1.A.1 Use the organization of the periodic table to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] 9-12.PS1.A.2Construct and revise an explanation for the products of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, or of oxygen and hydrogen.] 9-12.PS1.A.3 Plan and conduct an investigation to gather evidence to compare physical and chemical properties of substances such as melting point, boiling point, vapor pressure, surface tension, and chemical reactivity to infer the relative strength of attractive forces between particles. [Clarification Statement: Emphasis is on understanding the relative strengths of forces between particles. Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). 9-12.PS1.A.4 Apply the concepts of bonding and crystalline/molecular structure to explain the macroscopic properties of various categories of structural materials, i.e. metals, ionic (ceramics), and polymers. [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] 9-12.PS1.A.5 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.]
Structure and Properties of Matter		

B **Chemical reactions**	6-8.PS1.B.1 Develop and use a model to describe how the total number of atoms remains the same during a chemical reaction and thus mass is conserved. [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.] 6-8.PS1.B.2 Construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.]	9-12.PS1.B.1 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] 9-12.PS1.B.2 Refine the design of a chemical system by specifying a change in conditions that would alter the amount of products at equilibrium. [Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] 9-12.PS1.B.3 Use symbolic representations and mathematical calculations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on conservation of matter and mass through balanced chemical equations, use of the mole concept and proportional relationships.]
C **Nuclear Process**		9-12.PS1.C.1 Use symbolic representations to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.]

PS2 - Motion and Stability: Forces and Interactions		
Concept	**Middle School**	**High School**
A **Forces and Motion**	6-8.PS2.A.1 Apply physics principles to design a solution that minimizes the force of an object during a collision and develop an evaluation of the solution. 6-8.PS2.A.2 Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.]	9-12.PS2.A.1 Analyze data to support and verify the concepts expressed by Newton's 2nd law of motion, as it describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] 9-12.PS2.A.2 Use mathematical representations to support and verify the concepts that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] 9-12.PS2.A.3 Apply scientific principles of motion and momentum to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.]

B	6-8.PS2.B.1 Analyze diagrams and collect data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] 6-8.PS2.B.2 Create and analyze a graph to use as evidence to support the claim that gravitational interactions depend on the mass of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.] 6-8.PS2.B.3 Conduct an investigation and evaluate the experimental design to provide evidence that electric and magnetic fields exist between objects exerting forces on each other even though the objects are not in contact. . [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.]	9-12.PS2.B.1 Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational fields.] 9-12.PS2.B.2 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
Types of Interaction		

PS3 - Energy		
Concept	**Middle School**	**High School**
A **Definitions of Energy**	6-8.PS3.A.1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball.] 6-8.PS3.A.2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] 6-8.PS3.A.3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] 6-8.PS3.A.4 Plan and conduct an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the temperature of the sample. [Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.]	9-12.PS3.A.1 Create a computational model to calculate the change in the energy of one component in a system when the changes in energy are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] 9-12.PS3.A.2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] 9-12.PS3.A.3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.]

B **Conservation of Energy and Energy Transfer**	6-8.PS3.B.1 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.]	9-12.PS3.B.1 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.]

C **Relationship Between Energy and Forces**		9-12.PS3.C.1 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. . [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]
D **Energy in Chemical Process and Everyday Life**		

PS4 - Waves and Their Applications in Technologies for Information Transfer		
Concept	**Middle School**	**High School**
A **Wave Properties**	6-8.PS4.A.1Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] 6-8.PS4.A.2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.]	9-12.PS4.A.1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] 9-12.PS4.A.2 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.]
B **Electromagnetic Radiation**		9-12.PS4.B.1 Communicate technical information about how electromagnetic radiation interacts with matter. [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] 9-12.PS4.B.2 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.]

LS1 - From Molecules to Organisms: Structure and Processes		
Concept	**Middle School**	**High School**
A	6-8.LS1.A.1 Provide evidence that organisms (unicellular and multicellular) are made of cells and that a single cell must carry out all of the basic functions of life. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]	9-12.LS1.A.1 Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.]
Structure and Function	6-8.LS1.A.2 Develop and use a model to describe the function of a cell as a whole and ways parts of the cells contribute to that function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.]	9-12.LS1.A.2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.]
	6-8.LS1.A.3 Develop an argument supported by evidence for how multicellular organisms are organized by varying levels of complexity; cells, tissue, organs, organ systems.	9-12.LS1.A.3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.]
	6-8.LS1.A.4 Present evidence that body systems interact to carry out key body functions, including providing nutrients and oxygen to cells, removing carbon dioxide and waste from cells and the body, controlling body motion/activity and coordination, and protecting the body.	

B **Growth and Development of Organisms**	6-8.LS1.B.1 Construct an explanation for how characteristic animal behaviors as well as specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of animal behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds; and, creating conditions for seed germination and growth. Examples of plant structures that affect the probability of plant reproduction could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.] 6-8.LS1.B.2 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.]	9-12.LS1.B.1 Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms. [Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.]

C **Organization for Matter and Energy Flow in Organisms**	6-8.LS1.C.1 Construct a scientific explanation based on evidence for the role of photosynthesis and cellular respiration in the cycling of matter and flow of energy into and out of organisms.	9-12.LS1.C.1 Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] 9-12.LS1.C.2 Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] 9-12.LS1.C.3 Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules. [Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]
D **Information Processing**		

LS2 - Ecosystems: Interactions, Energy, and Dynamics		
Concept	**Middle School**	**High School**
A **Interdependent Relationships in Ecosystems**	6-8.LS2.A.1 Analyze and interpret data to provide evidence for the effects of resource availability on individual organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]. 6-8.LS2.A.2 Construct an explanation that predicts the patterns of interactions among and between the biotic and abiotic factors in a given ecosystem. [Clarification Statement: Relationships may include competition, predation, and symbiosis.]	9-12.LS2.A.1 Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations. [Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.]
B **Cycles of matter and Energy Transfer in Ecosystems**	6-8.LS2.B.1 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, including food chains and food webs.]	9-12.LS2.B.1 Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] 9-12.LS2.B.2 Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem. [Clarification Statement: Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one tropic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.] 9-12.LS2.B.3 Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.]

C	6-8.LS2.C.1Construct an argument supported by empirical evidence that explains how changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making inferences about changes in populations, defining the boundaries of the system, and on evaluating empirical evidence supporting arguments about changes to ecosystems.] 6-8.LS2.C.2. Evaluate benefits and limitations of differing design solutions for maintaining an ecosystem. [Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]	9-12.LS2.C.1 Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics. [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] 9-12.LS2.C.2 Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity. [Clarification Statement: Examples of solutions may include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, agriculture and mining programs, and ecotourism.]
Ecosyste6-8 Dynamics, Functioning and Resilience		
D		
Social Interactions and Group Behavior		

LS3 - Heredity: Inheritance and Variation of Traits		
Concept	**Middle School**	**High School**
A **Inheritance of Traits**		9-12.LS3.A.1 Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction.
B **Variation of Traits**		9-12.LS3.B.1 Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring 9-12.LS3.B.2 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] 9-12.LS3.B.3 Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] 9-12.LS3.B.4 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.]

LS4 - Biological Evolution; Unity and Diversity		
Concept	**Middle School**	**High School**
A **Evidence of Common Ancestry and Diversity**	6-8.LS4.A.1 Analyze and interpret evidence from the fossil record to infer patterns of environmental change resulting in extinction and changes to life forms throughout the history of the Earth. [Clarification Statement: Examples of evidence include sets of fossils that indicate an environment, anatomical structures that indicate the function of an organism in the environment, and fossilized tracks that indicate behavior of organisms.]	9-12.LS4.A.1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean written report, oral discussion, etc.) 9-12.LS4.A.2 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.]
B	6-8.LS4.B.1 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.] 6-8.LS4.B.2 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, and farming practices).]	9-12.LS4.B.1 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.)

Natural Selection		9-12.LS4.B.2 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]

C	6-8.LS4.C.1 Interpret graphical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.	9-12.LS4.C.1 Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.] 9-12.LS4.C.2 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.] 9-12.LS4.C.3 Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity. [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]
Adaptation		

D		
Biodiversity and Humans		

ESS1 - Earth's Place in the Universe		
Concept	**Middle School**	**High School**
A **The Universe and its Stars**	6-8.ESS1.A.1 Develop and use a model of the Earth-sun-moon system to explain the cyclic patterns of lunar phases and eclipses of the sun and moon. [Clarification Statement: Examples of models can be physical, graphical, or conceptual and should emphasize relative positions and distances.] 6-8.ESS1.A.2 Develop and use a model of the Earth-sun system to explain the cyclical pattern of seasons, which includes the Earth's tilt and directional angle of sunlight on different areas of Earth across the year. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.] 6-8.ESS1.A.3 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical or conceptual.]	9-12.ESS1.A.1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the Sun's core to release energy in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the Sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the Sun's radiation varies due to sudden solar flares ("space weather").] 9-12.ESS1.A.2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).] 9-12.ESS1.A.3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.]
B **Earth and the Solar System**	6-8.ESS1.B.1 Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.]	9-12.ESS1.B.1 Use Kepler's Law to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.]

C	6-8.ESS1.C.1 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.]	9-12.ESS1.C.1 Evaluate evidence of the past and current movements of continental and oceanic crust, the theory of plate tectonics, and relative densities of oceanic and continental rocks to explain why continental rocks are generally much older than rocks of the ocean floor. [Clarification Statement: Examples include the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).] 9-12.ESS1.C.2 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]
The History of Planet Earth		

ESS2 - Earth's Systems		
Concept	**Middle School**	**High School**
A **Earth Materials and Systems**	6-8.ESS2.A.1 Develop and use a model to illustrate that energy from the Earth's interior drives convection which cycles Earth's crust leading to melting, crystallization, weathering and deformation of large rock formations, including generation of ocean sea floor at ridges, submergence of ocean sea floor at trenches, mountain building and active volcanic chains. [Clarification Statement: The emphasis is on large-scale cycling resulting from plate tectonics that includes changes in rock types through erosion, heat and pressure.] 6-8.ESS2.A.2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]	9-12.ESS2.A.1 Develop a model to illustrate how Earth's interior and surface processes (constructive and destructive) operate at different spatial and temporal scales to form continental and ocean-floor features. [Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).] 9-12.ESS2.A.2 Analyze geoscientific data to make the claim that one change to Earth's surface can create changes to other Earth systems. 9-12.ESS2.A.3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [Clarification Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments. 9-12.ESS2.A.4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
B **Plate Tectonics and Large-Scale Systems**	6-8.ESS2.B.1 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. [Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).]	[

C **The Role of Water in Earth's Surface Processes**	6-8.ESS2.C.1 Design and develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] 6-8.ESS2.C.2 Research, collect, and analyze data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within possible ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).] 6-8.ESS2.C.3 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.]	9-12.ESS2.C.1 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or ice wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

D		
Weather and Climate		9-12.ESS2.D.1 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

E		
Biogeology		9-12.ESS2.E.1 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of coevolution include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for new life.]

ESS3 - Earth and Human Activity		
Concept	**Middle School**	**High School**
A	6-8.ESS3.A.1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes and human activity. [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]	9-12.ESS3.A.1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water, regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.] 9-12.ESS3.A.2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on economic, social, and environmental cost-benefit ratios. [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shale), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]
Natural Resources		

B **Natural Hazards**	6-8.ESS3.B.1 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]	
C **Human Impacts on Earth's Systems**	6-8.ESS3.C.1 Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of data include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change.] 6-8.ESS3.C.2 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]	9-12.ESS3.C.1 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] 9-12.ESS3.C.2 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems in order to restore stability and or biodiversity of the ecosystem as well as prevent their reoccurrences. [Clarification Statement: Examples of human activities could include forest fires, acid rain, flooding, urban development, pollution, deforestation, and introduction of an invasive species.]

D **Global Climate Change**	6-8.ESS3.D.1 Analyze evidence of the factors that have caused the change in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.]	9-12.ESS3.D.1 Analyze geoscientific data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] 9-12.ESS3.D.2 Predict how human activity affects the relationships between Earth systems in both positive and negative ways. [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.]

ETS1 - Engineering Design		
Concept	**Middle School**	**High School**
A **Defining and Delimiting Engineering Problems**	6-8.ETS1.A.1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	9-12.ETS1.A.1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. 9-12.ETS1.A.2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
B **Developing Possible Solutions**	6-8.ETS1.B.1 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. 6-8.ETS1.B.2 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. 6-8.ETS1.B.3 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	9-12.ETS1.B.1 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. 9-12.ETS1.B.2 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
C **Optimizing the Solution Process**		