Course Title: Advanced Science Studies

Board Approved: October 2026

Unit 1: Scientific Measurement and the Scientific Method	Time: 5 weeks

Academic Standards:

3.1.9-12.M: Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
3.2.9–12.B: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
3.1.9-12.L: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
3.2.9–12.A: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
3.4.9–12.E: Plan and conduct an investigation utilizing environmental data about a local environmental issue.
3.4.9–12.G: Analyze and evaluate how best resource management practices and environmental laws achieve sustainability of natural resources.
3.3.9–12.B: Evaluate or refine a technological solution that reduces the impact of human activities on natural systems.
3.4.9–12.C: Analyze and interpret how issues, trends, technologies, and policies impact watersheds and water resources.

Essential Content/Objectives: At the end of the unit, students will be able to:

1. Properly measure to the correct number of significant figures
    a. Temperature using analog and digital thermometers
    b. Atmospheric Pressure
    c. Volume with burets, pipettes, graduated cylinders, syringes
    d. Mass
    e. Distance with calipers
    f. Angle of Degree using an inclinometer
2. Choose the proper instrument with which to measure a quantity.
3. Maintain proper significant figures throughout calculations
4. Organize data into tables, charts and graphs as appropriate

Assessment:

1. Laboratory One - Making Measurements report complete with data table and analysis sections
2. Laboratory Two - Density of water report complete with abstract, background, data, analysis, and citations
3. Laboratory Three - Water Stratification based on density report complete with abstract, background, data, analysis, and citations
4. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:

5. Identify the principal source of error in an experiment and brainstorm and test to minimize this error
6. Explain how the density of water affects marine circulation and ecosystem diversity.
7. Define and use appropriately the following terms
    a. Thermocline
    b. Cavitate
    c. Gyre
    d. Upwelling
    e. Thermal expansion
    f. Kinetic Energy
    g. Line of best fit
    h. Correlation Coefficient
    i. Epilimnion, Metalimnion, Hypolimnion
    j. Niche
    k. Stratification
    l. Mean
    m. Density
8. Predict the species present in each layer of an aquatic ecosystem based on temperature
9. Predict the effect of wind on upper layer circulation

Core Student Activities: Students will complete/participate in the following:

1. Laboratory - Making Measurements
    a. Measure the dimensions of a wooden block to obtain volume
    b. Use mass by subtraction to determine the mass of a wooden block
    c. Determine the density of a wooden block to identify the type of wood
    d. Analyze statistical data to identify statistical significant datasets
    e. Prepare a report with a:
        i. Hypothesis
        ii. Background
        iii. Methods
        iv. Data and Analysis

a. Scientific method and reasoning: The student develops to create a working procedure with basic components of experimental design with control and independent and dependent variables

b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content.

c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

v. Conclusion that examines whether their data supports their hypothesis or not 2. Laboratory - Determine the density of water graphically at different temperatures a. Measure the mass and volume of different quantities of water at different temperatures b. Plot the mass vs volume and use the slope to determine the density of these different water samples. c. Use pipettes to measure precise quantities of water d. Compare expectations of densities based on kinetic theory with the experiment results they obtained in the laboratory. e. Infer how a water column would look regarding density and temperature and how this would influence circulation f. Prepare a report with a: i. Hypothesis ii. Background iii. Methods iv. Data and Analysis v. Conclusion that examines whether their data supports their hypothesis or not. 3. Laboratory - Water Stratification and Mixing a. Prepare a warm and cold layer of water and gently mix to create a stratified water column. b. Use food coloring to show the stratification visually c. Examine the effect of wind on the circulation of their water column by using a fan blowing across a tub at different speeds d. Create graphs showing the change in temperature over time relative to wind speed. e. Examine the column for signs of mixing and stratification f. Research primary methods of ocean circulation and the fish that exist in different layers of a water column g. Sketch naturalist drawings of different fish species. h. Prepare a report with a:	

i. Hypothesis ii. Background iii. Methods iv. Data and Analysis v. Conclusion that examines whether their data supports their hypothesis or not.	
Materials and Resources: ● Electronic Balances ● Water ● Tubs ● Digital and analog thermometers ● Calipers ● Hot plate ● Ice ● Food Coloring **Instructional Methods:** **Laboratory One:** Direct Instruction - Discussion of significant figures and uncertainty in measurement - Demonstration of use and introduction to various standard pieces of laboratory equipment - Essentials of Laboratory Safety Group Collaboration - Discuss and compare measurements - both in digits kept and in precision Laboratory Work - Record measurements of length, volume, mass, and temperature **Laboratory Two:** Direct Instruction - How to find the slope of a line - How to determine if a physical property is intensive or extensive - Why using a regression line reduces error Group Collaboration	**Extensions:** ● Measure temperature at different depths on a lake or river ● Create a graph of the water column at different time of day **Remediation:** ● Use gizmos and online labs to reinforce / introduce laboratory concepts ● Relevant Gizmo ● Coastal Winds Investigation

- Work with partner to record 5 different masses and volumes of water at a given temperature - Combine data from other groups Laboratory Work - Use methods of mass by subtraction and recording of volume **Laboratory Three:** Direct Instruction: - What is the macro effect of density of water on ocean circulation - How does wind mix water of different densities - Best practices for mixing water of different densities Group Collaboration: - Experimental design and discussion of how to set up the overrun scenario - Discuss with other groups their experimental set-ups and critique Laboratory Work: - Successfully mix hot and cold water so that a density thermocline is created and visualized with food coloring - Use a fan of different speeds to mix water	

Unit 2: Motion	Time: 5 weeks

Academic Standards:

3.3.9–12.D: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
3.2.9–12.B: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
3.2.9–12.F: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
3.2.9-12.I: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
3.2.9-12.J: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
*Please note - although these standards have the same titles "Forces and Interactions" the specific standards as listed are different for "I" and "J" despite their overall title being the same.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Explain how drag, mass, and gravity affect velocity and acceleration
2. Understand the interrelationships between forces - how one affects the others - for example, how mass affects friction
3. Optimize variables to produce the desired outcome - for example, the fastest car down a ramp.
4. Calculate **average velocity and acceleration** from experimental data.
5. Construct and interpret **motion graphs**.
6. Study how friction affects motion on an inclined plane.
7. Examine how changing surface materials alters the magnitude of frictional forces.
8. Observe how drag can influence motion and how to identify when it is significant.
9. See evidence that gravitational potential energy converts into kinetic energy during motion.
10. Design controlled experiments that isolate a single independent variable.
11. Draw and interpret **free body diagrams** for objects on an incline.
12. Analyze the role of experimental uncertainty on calculated acceleration

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.
2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:
   a. Scientific method and reasoning: The student develops to create a working procedure with basic components of experimental design with

values.

13. Create experimental conditions desired to test their variables from household materials
14. Measure and calculate the **period of oscillatory motion**
15. Determine that the **period of a pendulum depends on length**, not mass (within experimental limits).
16. Explore how gravity influences oscillatory systems.
17. Examine the conditions under which a model is valid (small-angle approximation).
18. Compare experimental results to theoretical predictions.
19. Students will learn the relationship between **rotational motion and translational motion**.
20. Identify how torque produces rotational acceleration.
21. Test how mass distribution affects moment of inertia.
22. Explore why solid spheres and cylinders accelerate differently down an incline.
23. Demonstrate evidence showing how gravitational potential energy is partitioned into translational and rotational kinetic energy.

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: Drag vs Friction
    a. Design lego cars that can be used to test effects of drag, mass, and friction on velocity and acceleration
    b. Observe the change in velocity over time and calculate relative acceleration
    c. Determine statistical differences in data sets
2. Laboratory: Period of a Pendulum
    a. Design a pendulum using ring stands, clamps, and rods
    b. Measure the period of a pendulum and determine which variables influence it by designing controlled experiments for mass, length, and starting angle (PE)
    c. Plot period length vs each of the variables tested to see which shows a relationship.

control and independent and dependent variables

b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content
c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

3. Laboratory: Rotational Motion and Torque a. Choose various spheres and cylinders to run controlled experiments comparing qualitatively the translational energy of the objects b. Control and test for mass, diameter, density, and shape c. Analyze the advantages of a solid wheel vs a hollow one and vice versa. Apply to bicycles and cars.	
Materials and Resources: ● Lego sets with wheels ● Wooden or metallic ramp with guardrails ● Weights and string and ring stands with rods ● Electronic Balance ● Stopwatches ● Spheres of different diameters and masses and solidity ● Cylinders of different diameters and masses and solidity ● Inclinometer **Instructional Methods:** **Laboratory One:** Direct Instruction - What is drag? What is the coefficient of drag? - How does mass influence acceleration and its role in comparison to the frictional force Group Collaboration - Discuss various lego designs that can be used to test high and low drag and create prototypes - Design cars for which one variable (drag) can be held constant but another (mass) can be changed Laboratory Work - Roll a car down a ramp and measure acceleration and average velocity - Physically build cars of different drags and weights **Laboratory Two:** Direct Instruction - What is a pendulum? What are they used for?	**Extensions:** ● Students build pendulum clock or a water clock and find ways to mediate loss of energy over time to timekeeping mechanism **Remediation:** ● Gizmo and online laboratories to reinforce learning or introduce concepts prior to laboratory ● Relevant Gizmo ● Period of a Pendulum

- What variables can be altered in a pendulum set-up and what do they mean - How is a pendulum used to keep time Group Collaboration - Discuss different lengths and weights and heights they plan to use for their pendulum and how they will time it - Critique pendulum set-ups of other groups Laboratory Work - Change the length of string, the mass of the weight, and the height of dropping weight on the period of a pendulum - Discern which variable DOES influence the period of the pendulum **Laboratory Three:** Direct Instruction - What is torque? What is translational motion vs rotational motion? - What is the difference in mass distribution for cylinder vs sphere Group Collaboration - Discuss predictions as to which type of object is likely to experience greatest acceleration and which would likely experience greatest final velocity Laboratory Work - Decide on which objects to roll down the ramp for purposes of a controlled experiment and then roll them down and record distance vs time - Determine which kind of shape will have the highest translational energy	

Unit 3: Microscopy	Time: 5 weeks

Academic Standards:

3.2.9–12.E: 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.
3.4.9–12.H: Design and evaluate solutions in which individuals and societies can promote stewardship in environmental quality and community well-being.
3.4.9–12.B: Apply research and analytical skills to evaluate the conditions and motivations that lead to conflict, cooperation, and change among individuals, groups, and nations.
3.2.9–12.A: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
3.4.9–12.C: Analyze and interpret how issues, trends, technologies, and policies impact watersheds and water resources.
3.1.9-12.E: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
3.1.9-12.D: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
3.1.9-12.C: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
3.1.9-12.A: 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.

Essential Content/Objective: At the end of the unit, students will be able to:

1. Prepare a wet mount slide and add dye to observe
2. Calculate the diameter and area of FOV of different magnifications
3. Focus accurately at different magnifications
4. Photograph at different magnifications
5. Measure size of cheek cell - eukaryote
6. Identify stomata and describe the role they play in plants
7. Analyze different stomata density in C3 and C4 plants along with top and bottom.
8. Understand why C4 plants have fewer stomata compared to C3
9. Collect samples of pond/river water and measure temperature at sampling site
10. Create wet mounts of water samples
11. Identify and distinguish between different protists and juvenile aquatic organisms

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.
2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: Sizing cells
   a. Students calculate the FOV at three different magnifications using a clear ruler at scanning power.
   b. Students use calculated FOV to size:
      i. Human cheek cells
      ii. RBC's from prepared slide
      iii. Neutrophils from prepared slide
      iv. Bacteria from prepared slide
   c. Compare experimental values vs known values to validate methodology.
2. Laboratory: Viewing and sizing stomata and guard cells
   a. Using nail polish and packing tape, create sides of the upper and bottom layers of leaf and determine the density and size of stomates in each
   b. Compare C3 and C4 plants in terms of stomates and speculate their niche in the ecosystem
   c. Compare sizes of stomata in C3 vs C4 plants.
3. Laboratory: Creating a wet mount of local pond water
   a. Collect three samples of pond water and preserve and bring to class
   b. Prepare we-mount slide of pond water (each sample)
   c. Act as naturalist and sketch, photograph, and identify species in samples

such as:

a. Scientific method and reasoning: The student develops to create a working procedure with basic components of experimental design with control and independent and dependent variables
b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content.
c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

Materials and Resources:

- Microscopes
- Slides and cover slips
- Iodine dye
- Sample containers
- Prepared slides of RBC and neutrophils
- Toothpicks
- Clear flat plastic rulers

Instructional Methods:
Laboratory One:
Direct Instruction

- What is FOV? How can the size of a FOV be measured

Extensions:

- Examine stomata before watering and after
- Examine specimens from different depths of water column

Remediation:

- Video support on the relationship between C3 and C4 plants.
- https://www.jove.com/science-education/v/10754/c4-pathway-and-cam-in-plants

- How to size a cell based on laboratory derived FOV - What is proper microscope technique and how do they work Group Collaboration - Compare size of RBC, bacteria, and plant cell with results from other groups and the known literature data Laboratory Work - Using a clear ruler find the FOV distance at 40x, 100x, and 400x - View slides of RBC, plant cells, and bacteria to determine the size at each cell **Laboratory Two:** Direct Instruction - What are stomata? What are guard cells? - What do plants use stomata for? When do they open and close and why? - C3 vs C4 vs CAM metabolism Group Collaboration - Find a source of C3 and C4 plants and nail polish - Help each other photograph the FOV with cell phone Laboratory Work - Using nail polish, create a sample of under and overside of leaves and count stomata - Compare stomatal density of C3 and C4 plants and compare to hypothesis **Laboratory Three:** Direct Instruction - What kind of organisms do we find in pond water? How to collect a sample? - What are protists? What are plankton? What are algae? Group Collaboration - Share pond samples with different lab groups - Discuss where the samples came from and what kind of organisms to expect - Share results of investigation with each other Laboratory Work - Prepare wet mount slides of pond water - Find at least five different organisms and identify and take pictures and using sizing technique from prior lab, size the organisms	

Unit 4: Basic Chemistry	Time: 5 weeks

Academic Standards:

3.2.9–12.E: 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

3.2.9–12.A: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

3.2.9–12.D: 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.

3.2.9–12.B: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

3.4.9–12.C: Analyze and interpret how issues, trends, technologies, and policies impact watersheds and water resources.

3.3.9–12.B: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, the motion of distant galaxies, and the composition of matter in the universe.

Essential Content/Objective: At the end of the unit, students will be able to:

a. Describe how substances combine in chemical reactions to form new substances with different properties.
b. Explain that atoms are conserved during chemical reactions even when gases are produced.
c. Apply the Law of Conservation of Mass to chemical reactions.
d. Represent chemical reactions symbolically and quantitatively.
e. Explain how system boundaries (open vs. closed) affect observable mass changes.
f. Describe how temperature influences reaction rate through collision frequency and energy.
g. Explain how thermal energy affects molecular motion and reaction rate
h. Define thermal energy and specific heat capacity.
i. Calculate heat transfer using $q = mc\Delta T$.
j. Explain how energy is transferred via radiation from a heat lamp.
k. Calculate power output using energy/time relationships.
l. Relate specific heat capacity to temperature change.
m. Explain how atomic structure and bonding influence thermal properties.
n. Relate mineral composition to macroscopic thermal behavior.

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.
2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:
    a. Scientific method and reasoning: The student develops to create a working procedure with basic components of

o. Describe how mineral composition varies geographically.
p. Explain how material properties influence environmental temperature regulation.
q. Define isotopes as atoms of the same element with different masses.
r. Explain how weighted averages determine atomic mass.
s. Relate isotope abundance to periodic table atomic mass values.
t. Explain surface oxidation as a chemical change.
u. Propose and evaluate methods to remove oxide layers.

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: Law of Conservation of Mass
    a. Conduct an acid base reaction to produce a gas in an open and a closed system.
    b. Diagnose potential sources of error in the experiment and their roles in the result such as leakage from their seal and the introduction of the vinegar
    c. Perform a control to compare data (just vinegar)
    d. Examine the effect of cooled or warmed vinegar on the rate of reaction
    e. Create data tables and graphs that communicate their findings accurately and in an organized way
2. Laboratory: Specific Heat Capacities
    a. Determine the power output of a heat lamp by measuring the change in temperature of a known quantity of water
    b. Using the calculated power output. Determine the relative specific heat capacities of sand from different regions of the NJ shore.
    c. Analyze which sand would heat/cool faster and how this might be observed in the "real" world.
    d. Propose an explanation and develop an argument as to why one sand might have a higher specific heat than another
    e. Test this hypothesis by determining the density of the sand and researching the different mineral compositions of the different sands
    f. Predict how the sand composition might impact the biotic community

experimental design with control and independent and dependent variables

b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content
c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

3. Laboratory: Isotopes a. Using pre and post 1982 pennies, determine the average atomic mass of a sample of pennies b. Use the average atomic masses and the average mass of pennies in the sample to predict how many pennies of each year are in the sample. c. Develop a procedure to remove the oxide coatings from both types of pennies.	
Materials and Resources: ● Baking soda ● Vinegar ● Erlenmeyer flasks ● Parrafilm wax ● Electronic balances ● Stirring rod ● Magnetic stir bars ● Sand ● Heat lamp ● Digital thermometers ● Calorimeters ● Pre and post 1982 pennies ● Salt (NaCl) **Instructional Methods:** **Laboratory One:** Direct Instruction - What are acids and bases? What are indications of chemical change? - What is the law of conservation of mass? Group Collaboration - Discuss quantities of each substance to be used for how long to run the experiment and how many times - Compare with other groups the loss in mass based on quantities used Laboratory Work	**Extensions:** ● Create Mass Spectra of pennium ● Find the specific heat capacity of soils ● Create particle drawings showing the law of conservation of mass **Remediation:** ● Gizmo and online laboratories to reinforce learning or introduce concepts prior to laboratory. ● Relevant Gizmo ● Calorimetry Lab

- In a beaker, mix different quantities of baking soda and vinegar and measure the change in mass as CO2 bubbles out - Calculate if the mass lost is the amount expected based on the reaction stoichiometry **Laboratory Two:** Direct Instruction - What is specific heat? What factors influence the specific heat capacity? - How can heat capacity be measured and the role of water? - Comparison of heat capacities of different substances Group Collaboration - Average specific heat values of different sized brass and bronze samples - Design an experiment to test the heat capacity of pennies Laboratory Work - Determine mass of metal sample, change in temperature when placed into a cool sample of water and calculate the specific heat capacity - Design an experiment in which the known heat capacity of a metal can be used to determine the expected change in temperature of water and test the hypothesis **Laboratory Three** Direct Instruction - What are isotopes? How is average atomic mass determined? - What is a weighted average? - Why do isotopes exist? Group Collaboration - Sort pennies into pre and post 1982 samples - Research why the composition of pennies changed Laboratory Work - Determine the average mass of pre and post 1982 penny - Predict - based on the mass of a random sample of pennies, what must be the composition of the mixture itself	

Unit 5: Naturalism and Ecology	Time: 5 weeks

Academic Standards:

3.1.9-12.I: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
3.1.9-12.H: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
3.1.9-12.J: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
3.1.9-12.L: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
3.1.9-12.N: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
3.1.9-12.T: 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
3.4.9-12.D: Apply research and analytical skills to systematically investigate environmental issues ranging from local issues to those that are regional or global in scope.
3.4.9-12.E: Plan and conduct an investigation utilizing environmental data about a local environmental issue.
3.4.9-12.H: Design and evaluate solutions in which individuals and societies can promote stewardship in environmental quality and community well-being.

Essential Content/Objective: At the end of the unit, students will be able to:

a. Sample multiple microecosystems and identify species present.
b. Estimate species abundance as a percentage of the community.
c. Calculate **Simpson's Diversity Index** for a microecosystem.
d. Calculate **Sørensen Similarity Index** to compare two ecosystems.
e. Interpret diversity indices to determine which areas are more or less diverse.
f. Analyze and explain the advantages and disadvantages of monoculture.
g. Evaluate the impact of microclimate and environmental conditions on biodiversity.
h. Identify birds in my local ecosystem using field guides or apps (Merlin, Audubon Society).
i. Infer habitat availability and quality based on observed bird species.
j. Propose and implement one habitat improvement to support local bird

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.

diversity.

k. Measure and evaluate the success of a habitat intervention over time.
l. Explain how changes in the environment affect species abundance and diversity.
m. Construct evidence-based arguments for improving habitat quality on the school campus.
n. Control variables such as temperature, moisture, and sunlight.
o. Measure and record plant growth over time and calculate germination timing.
p. Create a competition setup to observe effects of limited resources.
q. Graph growth data and compare rates between selectively bred and wild species.
r. Analyze how competition affects survival and resource allocation.
s. Use experimental evidence to explain natural selection and adaptation in plant populations.

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: Biodiversity
    a. Sample 4 different microecosystems and identify all species and make a rough count of how many are present as a percentage of the whole
    b. Use Identify This app to take pictures and corroborate species identification
    c. Calculate Simpson's index for each microecosystem and calculate Sorenson's index to check on diversity of microclimates and similarity of sampling areas
    d. Analyze the pros and cons of monoculture
    e. Identify more and less diverse areas on the high school campus
2. Laboratory: Bird Watching
    a. Using the Audubon Society Merlin app, identify the birds that call Wilson Area home
    b. Based on the bird's found, discuss what habitat is available to them
    c. Discuss and debate how the school's campus could be improved to promote more bird diversity

2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:
    a. Scientific method and reasoning: The student develops to create a working procedure with basic components of experimental design with control and independent and dependent variables
    b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content.
    c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

d. Propose, provide materials for, and engage in ONE campus alteration that will improve habitat and measure one month from start the success 3. Laboratory: Growth rates a. Plan and conduct an experiment that compares growth rate of vegetable seeds (selective breeding) and natural wildflowers/weeds. b. Control for temperature, moisture, and sunlight. c. Make daily measurements of height post germination along with time to germination d. Create a competition box where species are forced to compete for resources	
Materials and Resources: ● Hula hoops ● Identification app ● Calculator and spreadsheet ● Field notebooks ● Outdoor shoes and outerwear ● Seed mixes, cultivated and uncultivated ● Growing lamps ● Topsoil starter kits ● Construction materials ● Rulers **Instructional Methods:** **Laboratory One:** Direct Instruction - What is the simpson index? What is the sorensons coefficient? - Difference between diversity and evenness Group Collaboration - Predict which areas of school campus are likely to have high or low simpson index and which two areas would have most similar sorensons coefficient - Propose a local sampling site for a field trip Laboratory Work	**Extensions:** ● Sample an area around their home to find Simpson Index ● Bird watch in a different microecosystem to observe different birds in different habitats **Remediation:** ● Gizmo and online laboratories to reinforce learning or introduce concepts prior to laboratory. ● Relevant Gizmo ● Germination

- Using an identify app, identify and count the relative composition of species of flora in a sampling area
- Calculate simpson index for each sampling site and sorensons coefficient for the different sampling sites

Laboratory Two

Direct Instruction

- Classification schemes of birds and how to identify them based on song
- Ecological niches occupied by local birds

Group Collaboration

- Compare map and data of the school campus of bird song and relate to likely ecological niches
- Create a campus map of probable locations of finding different species of birds around the school

Laboratory Work

- Using cornell bird app, record bird song at different locations on campus and create map
- Using apriori information, hypothesis where we would expect song from different local birds

Laboratory Three

Direct Instruction

- What grasses and weeds are native to our area?
- How is growth rate measured?
- What is competition?

Group Collaboration

- Research which vegetables and weeds are C3 vs C4
- Discuss experimental design in how to create competition box

Laboratory Work

- Using seeds of vegetables and wildflowers/weeds create controlled experiments testing effect of moisture, sunlight, and soil type on successful competition
- Determine an optimal set of conditions in which a vegetable can outcompete a native weed/flower.

Unit 6: Electricity and Light	Time: 5 weeks

Academic Standards:

3.2.9-12.X: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

3.2.9-12.T: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

3.2.9-12.V: 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.

3.2.9-12.N: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

3.2.9-12.M: 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.

3.2.9-12.B: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

3.4.9-12.E: Plan and conduct an investigation utilizing environmental data about a local environmental issue.

Essential Content/Objective: At the end of the unit, students will be able to:

a. Explain that electric current is the flow of electric charge.
b. Relate the difference between voltage (electric potential difference), current, and resistance.
c. Define that voltage is energy per unit charge.
d. Identify current is measured in amperes and represents charge per unit time. and resistance opposes current flow and depends on material and geometry.
e. Calculate the mathematical relationship described by Ohm's Law (V = IR).
f. Understand the difference between series and parallel circuits in terms of how current and voltage distribute differently in series vs. parallel configurations.
g. Modify a circuit to change the current and voltage elsewhere in the circuit
h. Explain why removing one component in a parallel circuit does not stop current in other branches.
i. Identify that the brightness of a bulb is related to power dissipation.
j. Demonstrate that energy is conserved in electrical systems and transformed into light and heat.

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.
2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:

k. Classify materials as conductors, insulators, or semiconductors based on experimental evidence.
l. Rank materials by relative conductivity using measured data.
m. Explain conductivity in metals in terms of mobile electrons.
n. Explain conductivity in aqueous solutions in terms of mobile ions.
o. Compare the conductivity of different salt solutions at varying concentrations.
p. Predict how changes in concentration affect solution conductivity.
q. Interpret conductivity meter readings quantitatively.
r. Explain why pure water conducts poorly compared to salt solutions.
s. Compare electrical conduction in solids versus liquids.
t. Describe light as an electromagnetic wave.
u. Use the wave equation ($c = \lambda f$) to calculate wave speed, wavelength, or frequency.
v. Measure wavelength experimentally using spatial measurements of standing waves.
w. Calculate the speed of light using experimentally determined wavelength and reported frequency.
x. Analyze hydrogen spectral lines to determine wavelength and calculate wave speed
y. Compare two independent experimental methods to determine the speed of light
z. Evaluate sources of experimental uncertainty in wave measurements
aa. Calculate percent error and interpret its significance

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: Build & Break Circuits
    a. Build series and parallel circuits with bulbs
    b. Measure voltage across components
    c. Measure current in different configurations
    d. Predict and test what happens when a bulb is removed
    e. Compare brightness vs current
2. Laboratory: Conductivity
    a. Test common classroom objects for conductivity

a. Scientific method and reasoning: The student develops to create a working procedure with basic components of experimental design with control and independent and dependent variables
b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content.
c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

b. Rank materials from most to least conductive c. Test wet vs dry hands in a safe low-voltage circuit d. Discuss electrolytes and ionic conduction e. Compare different salts in terms of conductivity as well as concentration using conductivity meter 3. Laboratory: Speed of light Determination a. Determine the wavelength of microwave radiation in an oven by measuring the distance between melted and non-melted chocolate in oven b. Using the wavelength and reported frequency, determine the speed of light c. Measure the wavelength of red spectral line in hydrogen and use along with its reported frequency to find the speed of light d. Compare different methods for speed of light determination	
Materials and Resources: ● Microwave oven ● Chocolate ● Make and break circuit kit (3) ● Bulbs of different wattages and types ● Spectral tube and discharge box ● Conductivity meter ● Voltmeter and multimeter ● Batteries of different types ● Insulated gloves ● Salts and water ● 3 different metal wires ● Plastics ● Glass stirring rods **Instructional Methods:** **Laboratory One** Direct Instruction - What are parallel vs series circuits?	**Extensions:** ● Compare power drain of LED vs conventional bulb ● Use solar cell to identify optimum placement and mechanism **Remediation:** ● Gizmo and online laboratories to reinforce learning or introduce concepts prior to laboratory. ● Relevant Gizmo ● Advanced Circuits

- Define and describe voltage, current, and resistance - What is a multimeter and how to use? Group Collaboration - Compare circuit diagrams and proposed voltages and currents and positioning of components Laboratory Work - Build series and parallel circuits with bulbs - Measure voltage across components - Measure current in different configurations - Predict and test what happens when a bulb is removed - Compare brightness vs current **Laboratory Two:** Direct Instruction - What is an electrolyte? How is conductivity measured? - What factors affect conductivity in a solid? - How does dissociation of different salts affect conductivity Group Collaboration - Discuss which salts to test for electrolytic potential - Discuss which metals or materials would likely be least resistance to current Laboratory Work - Test common classroom objects for conductivity - Rank materials from most to least conductive - Test wet vs dry hands in a safe low-voltage circuit - Discuss electrolytes and ionic conduction - Compare different salts in terms of conductivity as well as concentration using conductivity meter **Laboratory Three:** Direct Instruction - What is light? What are microwaves? How much energy do they have? - How does a microwave heat up food? What is the reason for the grate that is seen in window of microwave? Group Collaboration - Research and compare the wavelength and reported frequency of chosen	

microwave oven - Determine who will bring in what materials Laboratory Work: - Determine the wavelength of microwave radiation in an oven by measuring the distance between melted and non-melted chocolate in oven - Using the wavelength and reported frequency, determine the speed of light and compare to the known value	

Unit 7: Environmental Health	Time: 5weeks

Academic Standards:

3.4.9-12.A: Analyze and interpret how issues, trends, technologies, and policies impact agricultural, food, and environmental systems and resource

3.4.9-12.H: Design and evaluate solutions in which individuals and societies can promote stewardship in environmental quality and community well-being.

3.4.9-12.G: Analyze and evaluate how best resource management practices and environmental laws achieve sustainability of natural resources.

3.4.9-12.E: Plan and conduct an investigation utilizing environmental data about a local environmental issue.

3.4.9-12.D: Apply research and analytical skills to systematically investigate environmental issues ranging from local issues to those that are regional or global in scope.

3.5.9-12.B: Critically assess and evaluate a technology that minimizes resource use and resulting waste to achieve a goal.

3.2.9-12.C: 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

Essential Content/Objective: At the end of the unit, students will be able to:

a. Analyze the relationship between water temperature and dissolved oxygen levels.
b. Conduct titration procedures to determine dissolved oxygen concentration.
c. Develop and test a hypothesis regarding thermal pollution impacts.
d. Interpret data to evaluate ecosystem health.
e. Compare natural water samples to potable water samples using quantitative data.
f. Research native and invasive aquatic species and evaluate tolerance to oxygen variation
g. Design and conduct an investigation to measure particulate deposition
h. Quantitatively analyze particle density across multiple environments.
i. Develop and test hypotheses regarding particle distribution.
j. Evaluate relationships between particulate matter and public health data.
k. Interpret findings in the context of environmental justice and community health.
I. Compare eutrophic and non-eutrophic aquatic systems using observational

Assessment:

1. Three laboratory reports graded on rubric for accuracy, technique, quality of analysis, and presentation. Each report will vary in terms of formality. At least one of these reports will be student generated with an abstract, background, procedure, data, and analysis sections. The other reports will be necessarily less comprehensive but will - at a minimum - contain organized data and analysis sections where the student revisits their hypothesis and discusses how the data supports or does not support the hypothesis and how.
2. Students evaluated daily on a rubric. Evidence for learning is broken into a variety of topics such as:
    a. Scientific method and reasoning: The

and chemical data.

m. Analyze algal density using structured sampling techniques.
n. Conduct precipitation reactions to evaluate phosphate removal methods.
o. Determine which metal ions are most effective at reducing phosphate concentration.
p. Evaluate preventative versus reactive environmental strategies.
q. Propose evidence-based solutions to nutrient pollution.
r. Define environmental problems.
s. Develop testable hypotheses.
t. Collect and analyze quantitative data.
u. Design and evaluate remediation strategies.
v. Communicate findings using scientific argumentation.

Core Student Activities: Students will complete/participate in the following:

1. Laboratory: DO Measurements
    a. Sample at multiple locations around a lake or river (one in shade and other in sunlight) and measure the temperature at that location.
    b. Use titration method to test for DO levels in each location
    c. Analyze results of the tests to test a hypothesis of thermal pollution affecting our aquatic systems
    d. Research local aquatic life and search for evidence of transplanted species.
    e. Compare natural DO levels to that of school water samples.
2. Laboratory: Testing Air Quality
    a. Create testing kits of pads with petroleum jelly
    b. Locate places in the classroom, school, and home to place air traps
    c. After 48 hours, examine pad under microscope and identify, count, and photograph particle density
    d. Relate the results of their study to increased rates of asthma in urban vs rural areas.
    e. Test a hypothesis of where the most particles in the air might be found along with the least
3. Laboratory: Eutropication

student develops to create a working procedure with basic components of experimental design with control and independent and dependent variables

b. Collaboration and interest: The student is an active participant in the logistics, planning and recording in the lab. They are willing, friendly , and endeavor to assist in all tasks. The student brainstorms ways to improve their experiment or add extensions or other variables to study. The student actively contributes to class discussion and engages with the teacher on the content.
c. Productivity: The student is on task for the period and uses their time efficiently to accomplish tasks. The student is accurate in the making and recording of data.

a. Sample water from clear vs eutrophied ponds b. Develop a procedure to test for algal density and for phosphate removal via precipitation c. Add various metals ions and see which is MOST effective at removing phosphate ions from controlled prepared solutions vs natural samples d. Research common algal blooms and the origin of the phosphate along with remedies to mediate the problem - an ounce of prevention is worth a pound of cure.	
Materials and Resources: ● DO testing kits ● Calcium nitrate or magnesium chloride ● Filter paper ● Aquarium tank ● Sampling containers ● Field thermometers and notebooks ● Petroleum jelly ● Microscopes **Instructional Methods:** **Laboratory One** Direct Instruction - What is dissolved oxygen and what is its importance in ecosystems - What factors influence the solubility of a gas and how this is changing due to human impacts? - How is DO tested? Group Collaboration: - Research DO levels needed for organisms and compare - Collate each groups DO measurements Laboratory Work: - Sample at multiple locations around a lake or river (one in shade and other in sunlight) and measure the temperature at that location. - Use titration method to test for DO levels in each location - Analyze results of the tests to test a hypothesis of thermal pollution affecting	**Extensions:** ● Create an environmental health document for the school outlining areas that could improve ● Create an algal bloom in an aquarium - humane without fish but test then for DO levels **Remediation:** ● Gizmo and online laboratories to reinforce learning or introduce concepts prior to laboratory. ● Relevant Gizmo: ● https://ee2-nitk.vlabs.ac.in/exp/oxygen-in-water/simulation.html

our aquatic systems - Research local aquatic life and search for evidence of transplanted species. - Compare natural DO levels to that of school water samples. **Laboratory Two** Direct Instruction - What materials are found in the air? - What materials are found in the air due to human impact? - What is the physiological effect of these materials in the air Group Collaboration - Research the smoggiest cities of the world and compare findings. - Research our own local air quality numbers compared to other areas or jurisdictions based on air quality laws - Coordinate testing areas in school and community Laboratory Work - Create testing kits of pads with petroleum jelly - Locate places in the classroom, school, and home to place air traps - After 48 hours, examine pad under microscope and identify, count, and photograph particle density - Relate the results of their study to increased rates of asthma in urban vs rural areas. - Test a hypothesis of where the most particles in the air might be found along with the least **Laboratory Three** Direct Instruction - What is eutrophication and what causes it? - What is the impact of eutrophication on aquatic life and why? Group Collaboration - Compare pictures of eutrophication from classmates around our area - Brainstorm a laboratory set-up that could create an algal bloom Laboratory Work - Sample water from clear vs eutrophied ponds - Develop a procedure to test for algal density and for phosphate removal via precipitation	

- Add various metals ions and see which is MOST effective at removing phosphate ions from controlled prepared solutions vs natural samples - Research common algal blooms and the origin of the phosphate	