Randolph Township Schools
Randolph High School

Biology Curriculum

"Nothing in Biology makes sense except in the light of evolution."

Theodosious Dobzhansky

Department of Science, Technology, Engineering, and Mathematics
Stacy Winters, Supervisor

Curriculum Committee
Ruth Forrest
Liz Meehan

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Randolph Township Schools
Department of STEM
Biology

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Randolph Township Schools

Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Randolph Township Schools
Affirmative Action Statement

Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

RANDOLPH TOWNSHIP BOARD OF EDUCATION
EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

Randolph Township Schools
Department of STEM
Biology

Introduction

Biology is a required course which is taught in the freshman year to all students. The course builds upon earlier Life Science concepts which were learned in middle school.

Students progress from an understanding of organic molecules through the structure and function of cells to how cells unite in an organized way to form tissues in multicellular organisms. The relationship between structure and function and the diversity of life, shaped by evolution, is the underlying theme of the course. How life maintains and reproduces itself is studied in detail, followed by the interrelationships of different species as seen in ecological systems. These matters are critical to students' understanding of their own bodies and of the natural world on which they depend. The understanding of biological systems makes it possible for students, as they grow into adult citizens, to make informed medical decisions, lifestyle choices, and to participate intelligently in discussions of ethics and policy that increasingly depend upon biological foundations in the modern world.

Major units in the Biology course are The Cell and Biochemistry; Structure and Functioning of Multicellular Organisms; Genetics and Heredity; Evolution and the History of Life, and Ecology and Ecosystem Functioning. All concepts are taught within an inquiry-infused framework. Laboratory periods are provided once or twice per week, during which time students participate in hands-on investigations and explorations of the phenomena being studied. The practice of science is not only taught but experienced, as a key factor in any science course is answering the questions "How do we know what we know?" and "What do we still not understand?" Teachers use a mixture of instructional strategies including formal labs, model-building exercises, whole and small group instruction, discussions, case studies, and student-directed investigations.

The Biology curriculum is fully aligned with the Next Generation Science Standards, which are now known as the New Jersey Student Learning Standards. These standards and the goals established by the Randolph Township Board of Education will guide the course. Students in the Biology course frequently engage in activities that are also aligned with the New Jersey State Common Core Content Standards for English Language Arts; New Jersey Technology Standards, and the New Jersey State Common Core Content Standards for Mathematics.

The standards include a "three-dimensional learning" model which emphasizes large, transferable concepts and the practices of science and engineering. This curriculum has been designed with these directives in mind. The "Crosscutting Concepts" appear in every unit and in every lesson. "Science and Engineering Practices" are also infused into the curriculum. Both are listed in the table in Appendix A. These processes represent skills that repeat and improve for students over several years of science study, including this course.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Curriculum Pacing Chart
Biology

SUGGESTED TIME ALLOTMENT Total = 36 weeks	UNIT NUMBER	CONTENT - UNIT OF STUDY
8 weeks	I	From Atoms to Cells: Life and Biochemistry
6 weeks	II	From Cells to Organisms: Structure and Function
8 weeks	III	Genetics and Information Transfer
7 weeks	IV	Evolution and the History of Life
7 weeks	V	Ecology and Ecosystem Functioning

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
UNIT I: From Atoms to Cells: Life and Biochemistry

<table>
<tr><td rowspan="8">New Jersey Student Learning Standards – Disciplinary Core Ideas for Grades 9-12 Life Science

LS1.A Structure and Function
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. Feedback mechanisms can encourage (through positive feedback) and discourage what is going on inside the living systems.

LS1.C Organization for Matter and Energy flow in Organisms
The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen

The sugar molecules thus formed contain carbon, hydrogen, and oxygen; their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) used for example to form new cells.</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>All life is composed of a small set of molecules which are used in relatively common ways but result in the variety that we see.</td><td>• How do chemical reactions result in biological processes?</td></tr>
<tr><td>Cells control their internal environment to maintain stability within limits.</td><td>• What is necessary to maintain life?</td></tr>
<tr><td>Metabolic processes such as cellular respiration and photosynthesis are complex chains of controlled reactions that manage energy transfer and storage within cells.</td><td>• What are bodies made of?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

Most cell functions involve chemical reactions in specialized structures.

Organic molecules are polymers that are formed and broken by enzyme-controlled processes.

Enzymes are organic catalysts that respond to temperature, pH, salinity, concentration, and interference.

Carbohydrates are used primarily as sources of energy and for body structure; Lipids are used to store energy in the cell and to form membranes; Nucleic acids store and process the information necessary to make proteins.

Most structural and functional elements of a cell are proteins, some of these are enzymes. Cells constantly construct proteins, some of which are secreted.</td><td>Students will be able to:

Use an analogy or metaphor to describe the structure and function of the organelles in a eukaryotic cell.

Model the processes of dehydration synthesis and hydrolysis.

Predict and explain behavior of an enzyme in experimental situations.

Directly compare the structure, size, and variety of carbohydrates, lipids, proteins, and nucleic acids to each other.

Model the process of creating a protein for secretion, locating each step at its particular place in the cell.</td></tr>
</table>

As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	The nutritional needs of particular organisms are explainable by the properties of lipids, carbohydrates, proteins, and nucleic acids. Photosynthetic cells use solar energy to combine molecules of carbon dioxide and water into carbohydrates, oxygen is released as a waste. Aerobic cellular respiration is a process in which glucose is broken down and its energy transferred to ATP; carbon dioxide and water are released as waste. Anaerobic respiration, or fermentation, produces incompletely broken down molecules with significant remaining energy. The global carbon cycle is driven by photosynthesis, cellular respiration, combustion, and decomposition. The cell membrane is structured to allow it to actively control the passage of matter into and out of the cell. **Key Terms and Concepts** Covalent bonding, molecule, organic, polymer, metabolism**,** carbohydrate, protein, lipid, nucleic acid, membrane, aerobic, respiration, fermentation, light reactions, Calvin cycle, citric acid cycle, glycolysis, carbon cycle, enzyme	Decode and analyze actual food nutrition and ingredient labels. Research the effects of malnutrition and under nutrition in humans. Use a model to demonstrate step by step how photosynthetic organisms create carbohydrates within chloroplasts. Relate the structure to the function and origin of a chloroplast. Use a model to demonstrate step by step how cells extract energy from glucose using mitochondria. Relate the function of mitochondria to their structure and origin. Explain why the products of fermentation are often useful human foods. Compare the processes of respiration and combustion. Model the carbon cycle and the effects of human activity on it. Propose management or technical solutions based on data. Model the reactions of a cell to different internal and external concentrations of solutes. Compare different routes of entry and exit into and out of the cell.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Constructing and revising an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules (HS-LS1-6)
- Using models to illustrate how photosynthesis transforms light energy into stored chemical energy (HS-LS1-5)
- Using models to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy (HS-LS1-7)
- Planning and conducting an investigation to provide evidence that feedback mechanisms maintain homeostasis (HS-LS1-3)

KEY LEARNING EVENTS AND INSTRUCTION:

- Suggested labs and performance assessments: pH testing, food testing, properties of water, organic molecule structures, enzyme activity (e.g. catalase), modeling of photosynthesis and respiration, fermentation testing, carbon cycle game
- Presentation of findings from experimental labs in poster, presentation, or written reports

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
Unit I: From Atoms to Cells: Life and Biochemistry

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
8 Weeks	• Review of atomic structure and of cell structure • Special properties of carbon and of water • Organic molecules and their properties • How polymers form and break • Thermodynamics and Enzymes • The cell membrane and cell transport mechanisms • Cellular respiration and fermentation • Photosynthesis • The carbon cycle, combustion, and fossil fuels	• PhET interactive simulations https://phet.colorado.edu/en/simulations/category/biology and https://phet.colorado.edu/en/simulations/category/chemistry • Cell biology animations by John Kyrk http://johnkyrk.com/ • Virtual Cell Labs http://bio.rutgers.edu/~gb101/virtuallabs_101.html • University of Wisconsin – Online Animations https://www.wisc-online.com/learn/natural-science/life-science

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
UNIT II: From Cells to Organisms: Structure and Function

<table>
<tr><td rowspan="8">New Jersey Student Learning Standards – Disciplinary Core Ideas for Grades 9-12 Life Science

LS1.A Structure and Function
Systems of specialized cells within organisms help them perform the essential functions of life.

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 mechanisms can encourage or discourage what is going on inside the living system.

LS1.B: Growth and Development of Organisms
In multicellular organisms individual cells grow and then divide by a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell that divides successively to produce many</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Cells are able to make new cells through growth and reproduction in an organized way. Growth, development, and cancer are all part of the same fundamental processes</td><td>• How does life reproduce?</td></tr>
<tr><td>Tissues, organs, and body systems in multicellular organisms are based on the properties and interactions of cells.</td><td>• How does a functioning multicellular organism develop from one cell?</td></tr>
<tr><td>Multicellular bodies require sophisticated communications systems involving information processing and feedback</td><td>• How do bodies communicate within themselves? What do they say?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

There are fundamental differences between animal, plant, fungal, and bacterial cells which reflect the different life strategies of those groups.

Multicellular organisms are constructed from a hierarchy of cells which form tissues, organs, and organ systems.

Although every cell in a multicellular organism has the same genetic material, differences are created by growth patterns resulting from the expression of only some of the genes in each cell.

A multicellular body requires systems for cell to cell communications; these may include chemical and electrical signals.</td><td>Students will be able to:

Deduce the nutritional needs and mode of an organism based upon information about the structure of its cells.

Use data to infer how example organs support life functions in different organisms.

Describe how an example organ system develops.

Plan an investigation of cell to cell communications (for example, plant transpiration or hormone responses).</td></tr>
</table>

cells, with each parent cell passing identical genetic material to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	Feedback systems control the organism; these systems may use positive or negative feedback mechanisms to maintain homeostasis. Organisms function by a combination of controlled growth and development, intracellular biochemical processes, and behavior. All reproduction involves the replication of DNA molecules in a complex process that is mediated by enzymes. Mutations are changes to DNA sequences that may result from mistakes in replication; they are passed on to daughter cells. The resulting changes in the proteins made may help, harm, or have little or no effect on the offspring's success in its environment. Cancer is caused by defects in the cell signaling that controls mitosis; problematic symptoms result from an imbalance of body systems due to overgrowth. **Key Terms and Concepts** Gene, chromosome, mutation, mitosis, binary fission, differentiation, replication, clone, tissue, organ, osmosis, diffusion, cancer, oncogene, cell cycle, hormone.	Construct a model which demonstrates the operation of feedback mechanisms that control the behavior of an organism, such as the action of insulin or other examples. Explain how an example organ supports the basic life processes of cells in the organism by tracing a sequence of events that occur in that organ system. Use a model to demonstrate the process of DNA replication, chromosome condensation, and movements of mitosis. Use a model to demonstrate the specific types of mutations to DNA that are possible such as insertions, deletions, and translocations. Use data to construct and revise an explanation of the relative contribution of various risk factors to the development of cancer in humans.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Constructing 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 **(**HS-LS1-1)
- Developing and using models to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms **(**HS-LS1-2)
- Using models to illustrate the role of cellular division (mitosis) and differentiation in maintaining complex organisms **(**HS-LS1-4)

KEY LEARNING EVENTS AND INSTRUCTION:

- Suggested labs and performance assessments: Microscopic examination of cells in various Kingdoms, modeling of an endocrine subsystem (e.g. insulin signaling), observations of embryological development (sea urchin, snail, zebra fish, plant germination), use or build DNA structure models to demonstrate mutations, modeling of mitosis with manipulatives, investigation of cancer treatments and how they work (library research), microscopic examination of tissues, experimental manipulation of factors affecting the growth of an organism (e.g. plant growth, yeast or bacterial colonies)

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
Unit II: From Cells to Organisms: Structure and Function

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
6 Weeks	• Cell reproduction- mitosis and binary fission • Cell to cell communications • Cancer • Histology- how cells connect and form organs • Positive and negative feedback loops in living organisms • Basic development- how fertilized eggs become differentiated multicellular organisms • Introduction to gene expression • Fundamental adaptations of the Kingdoms of life	Web resource: • Cells Alive! http://www.cellsalive.com Suggested videos: • PBS "Cancer Warrior" • National Geographic "Inside the Animal Womb" • Discovery Channel "Life: Episode 9 Plants"

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
UNIT III: Genetics and Information Transfer

<table>
<tr><td rowspan="8">New Jersey Student Learning Standards – Disciplinary Core Ideas for Grades 9-12 Life Science

LS1.A Structure and Function
All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.

LS3.A Inheritance of Traits
Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. All cells in an organism have the same genetic content, but the genes expressed by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as yet known function.

LS3.B: Variation of Traits
In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis, thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly</td><td>ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td>Genetic information is encoded in nucleic acids and passed from cell to cell as they divide.</td><td>• How are characteristics passed from one generation to another?</td></tr>
<tr><td>DNA is a molecular string of genetic code that directs the assembly of proteins, which are manifested in structures, behaviors, or physiological capabilities.</td><td>• Why are we both like and unlike our relatives?</td></tr>
<tr><td>Protein synthesis is an ongoing activity that allows organisms to survive, develop specific structures, react to their environments, and reproduce</td><td>• Where do new traits come from?</td></tr>
<tr><td>The patterns of inheritance that are seen reflect the physical movement of chromosomes during cell division.</td><td>• How does the genetic endowment of an organism interact with its behavior and environment?</td></tr>
<tr><td>KNOWLEDGE</td><td>SKILLS</td></tr>
<tr><td>Students will know:

DNA molecules carry the blueprint that controls protein synthesis.

One DNA molecule (chromosome) contains many hereditary factors called genes. Each gene codes for a particular set or family of proteins.

RNA acts as a molecular catalyst between DNA and proteins; it conducts a wide variety of functions to control the synthesis of proteins.

Not all DNA codes for protein. Some segments of DNA are involved in regulatory or structural functions, and some have no yet known function.</td><td>Students will be able to:

Create a model that demonstrates the flow of genetic information from DNA to RNA to proteins.

Use a codon chart to derive primary protein structure from an mRNA sequence.

Demonstrate the flow of information from a gene to RNA to a completed protein using models.

Map an example chromosome, including the nature and sources of different sequences including any of the following: genes, rflps, transposons, ghost genes, gene duplications, RNA genes, and STRs.</td></tr>
</table>

regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations in germ line cells are inherited. Environmental factors also affect expression of traits. Thus the observed variation and distribution of traits in a population depends upon both genetic and environmental factors.	Sexual reproduction, based on meiosis, is nearly universal in eukaryotes because it dramatically increases genetic variety in several ways. The laws of probability, applied to chromosome movements, predict the possible genotype distributions of offspring. A variety of human conditions are caused by abnormal or unusual dosage patterns. Only the mutations in germ cells (eggs and sperm) are passed to an organism's offspring. The two copies (alleles) of each gene may interact with each other and with other genes in many ways, resulting in a blended trait or the visible presence of only one version of the trait in diploid organisms. Biotechnology techniques make it possible to directly read and manipulate DNA sequences and the proteins made from them as well as eliminate genes or move them from one organism to another. Gene expression is controlled by a variety of cell signals driven by both the internal and external environment of the organism. **Key Terms and Concepts** Gene expression, protein dose, germ line, dominant, recessive, codominant, allele, meiosis, crossing over, gamete, sexual reproduction, zygote, embryo, messenger RNA, ribosome, triplets, codons, transfer RNA, transgenic, intron,	Demonstrate how sexual reproduction enhances variety by crossing over, independent assortment, and random fertilization. Use probability theory to predict the outcome of monohybrid and dihyrid crosses. Predict the chromosomal abnormalities that would result from various problems during the process of meiosis. Show how the movements of chromosomes in meiosis and fertilization could result in abnormal numbers of chromosomes. Describe the mechanisms and the results of X-inactivation in mammals. Compose an explanation for why acquired characteristics and somatic mutations cannot be passed to offspring. Interpret a pedigree to establish the mode of inheritance of a trait. Research examples of various modes of inheritance, including dominance, co-dominance, incomplete dominance, epistasis, pleiotropy, and polygenesis. Develop an explanation for the mechanism of hybrid vigor. Research actual examples of transgenic organisms that affect our lives today. Debate the ethics and safety involved in genetic engineering in organisms. Relate a human trait such as lactose intolerance or amylase production to the process of gene expression.

	exon, base pairing, nucleotides, amino acids, X-linked, genome.	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Asking questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring **(**HS-LS3-1)
- Making and defending 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 **(**HS-LS3-2)
- Applying concepts of statistics and probability to explain the variation and distribution of expressed traits in a population (HS-LS3-3)

KEY LEARNING EVENTS AND INSTRUCTION:

- Suggested labs and performance assessments: Protein synthesis modeling using manipulatives (e.g. beads, straws, pool noodles, etc.), applying codon charts to decode genes, investigating protein sequences using online databases, modeling meiosis using manipulatives, bioethics debates, study of human genetic disorders including both chromosomal and allelic problems, create pedigrees from data, explore and apply probability to predicting the outcome of genetic crosses, reproducing small organisms asexually, collect data and calculate the frequency of human traits like lactose intolerance, gluten intolerance, PTC tasting, etc., selected activities from the University of Utah Learn Genetics website
- Use Punnet squares and (in some cases) probability calculations to predict the outcome of genetic crosses, or to work backwards from data to inferred relationships between alleles in a cross

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
Unit III: Genetics and Information Transfer

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
8 Weeks	• Structure of DNA and RNA • Process of protein synthesis • Meiosis and sexual life cycles • The sources of genetic variability • Mendelian inheritance genetics • Human genetic disease • Genetic technologies and bioethics	Suggested videos: • GATTACA • PBS "DNA Episode 1: The Secret of Life" • PBS "DNA Episode 3: The Human Race" • PBS "DNA Episode 2: Playing God" • PBS "DNA Episode 4: Curing Cancer" • PBS "DNA Episode 5: Pandora's Box" Suggested web resources: • DNA: From the Beginning http://www.dnaftb.org/ • Learn.Genetics by University of Utah http://learn.genetics.utah.edu • Genetic Animations by DNALC https://www.dnalc.org/resources/animations/ Suggested game-based resources: • Geniverse (Inquiry-based genetics modeling program) https://concord.org/projects/geniverse

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
UNIT IV: Evolution and the History of Life

New Jersey Student Learning Standards – Disciplinary Core Ideas for Grades 9-12 Life Science	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
LS3.B Variation of Traits Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. **LS4.A Evidence of Common Ancestry and Diversity** Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. **LS4.B Natural Selection** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information – that is, trait variation – that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **LS4.C Adaptation** Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and	Natural selection explains the biodiversity found on Earth.	• Why are there so many different species?
	Variability arises in populations by random mutations; some of these result in better reproductive success than others; therefore, beneficial changes endure and accumulate in populations.	• Why does evolution exist?
	The specific conditions of a population's environment determine which heritable traits are adaptations.	• How does one species affect the evolution of another species?
	KNOWLEDGE	**SKILLS**
	Students will know: Evolution is a defining property of all life. All life shares a common cellular structure and genetic code since all species diversity developed from an earlier, common ancestor. Changes in the genetic composition and in the body forms of species can be traced through the fossil record, comparative anatomy and embryology, and molecular genetics. Evolution is the study of the genetics of populations. Variations arise by mutation but are selected for or against persistence by the environment.	**Students will be able to:** Compare the degree of relatedness between species using molecular data. Summarize the history of life on Earth using a timeline or phylogenetic tree. Model or describe the biological species concept in terms of gene pools. Simulate the change in allele frequencies of a population over time. Explain the relationship of variation and mutation to natural selection.

reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. Adaptation also means that the distribution of traits in a population can change when conditions change. Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline - and sometimes the extinction – of some species. Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. **LS4.D Biodiversity and Humans** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **ETS1.B Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	The traits acted upon by natural selection include body form, biochemistry, internal functioning, and life history. New species arise when a preexisting species becomes separate from itself via reproductive isolation. Evolution has no inherent direction and cannot be predicted except on the basis of a deep understanding of the ecological situation of the population. Evolutionary changes can be observed today in the processes of artificial selection, evolution of antibiotic-resistant diseases, pesticide-resistant insects, and geographically separated subspecies. The pace of evolution is responsive to the generation time of the species, environmental change, and the size of the population. A systematic comparison of traits among species allows us to infer their evolutionary history and relatedness. Sexual recombination alone does not cause evolution. The process of evolution primarily results from the potential for a species to increase in number, the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, competition for limited resources, and the proliferation of those organisms that are better able to survive and reproduce in the environment. Selection may result in directional changes in a population or it may preserve or restrict variation based on the situation. A population's niche will serve to help direct its evolution. Life on Earth has been characterized by mass extinction events followed by extensive adaptive radiation of surviving forms. The genetic information lost when a species becomes extinct can never be recovered.	Compare the validity of the idea of evolution by natural selection with the use and disuse of structures (Lamarckian reasoning). Discuss contemporary examples of coevolution and sexual selection. Model the emergence of a new species using gene pool and environmental data. Describe environmental and population factors that would speed up or slow down the process of natural selection. Explain contemporary examples from nature which demonstrate the process of natural selection. Explain the process of punctuated equilibrium and its effect on a given population. Relate evolutionary history to current classification and taxonomic categories such as Kingdoms. Explain the main factors that result in the evolution of populations over time and track changing allele frequencies using population data. Interpret the type of selection acting on a population from data. Explain why no two species can occupy the same niche. Model the adaptive radiation that resulted in present day species.

Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	Variation is the raw material of evolution; Populations with too little variation and too few members are subject to non-adaptive changes such as genetic drift and the bottleneck effect. **Key Terms and Concepts** Population, adaptation, natural selection, artificial selection, sexual selection, fitness, genotype, phenotype, adaptive radiation, phylogeny, species, gene pool, extinction, genetic drift, reproductive isolation, biodiversity.	Use a mathematical model to demonstrate the long-term effects of a small change in reproductive success and random changes that affect small population sizes.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Applying concepts of statistics and probability to explain the variation and distribution of expressed traits in a population **(**HS-LS3-3)
- Communicating scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence **(**HS-LS4-1)
- Constructing 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 (HS-LS4-2)
- Applying 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 (HS-LS4-3)
- Constructing an explanation based on evidence for how natural selection leads to adaptation of populations (HS-LS4-4)
- Evaluating the evidence supporting claims that changes in environmental conditions may result in: (1) increase in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species (HS-LS4-5)
- Creating or revising a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity (HS-LS4-6)

KEY LEARNING EVENTS AND INSTRUCTION:

- Suggested labs and performance assessments: Human adaptations, Evolution and genetics (shifting allele frequencies), natural selection simulations such as Dots Lab, interpreting population data and allele frequencies to determine evolution of populations, speciation simulations

Biology
Unit IV: Evolution and the History of Life

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
7 Weeks	• Common ancestry: analyzing molecular data, physical adaptations, present examples • Allele frequencies and evolution • Causes of evolution/change in allele frequency (natural selection, gene flow, mutation, genetic recombination, genetic drift) • The process of natural selection • Adaptation, adaptive radiation, and systematic phylogeny • Speciation processes • Types of selection pressures, e.g. directional, stabilizing, and diversifying • History of mass extinctions	Suggested videos: • PBS "Evolution" Series, • PBS "What Darwin Never Knew", • BBC "Life of Mammals-Persistence Hunt clip • Discovery Channel Cosmos "Origin of Life" episode Suggested game-based resource: • The Radix Endeavor: http://www.radixendeavor.org Suggested web resource: • The Five Fingers of Evolution by Paul Anderson http://ed.ted.com/lessons/five-fingers-of-evolution

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
UNIT V: Ecology and Ecosystem Functioning

New Jersey Student Learning Standards – Disciplinary Core Ideas for Grades 9-12 Life Science	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
LS2.A Interdependent Relationships in Ecosystems Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. 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.	The quantity of matter remains constant in Earth's system and cycles from one organism to another, and between organisms and their physical environment.	• Where did the matter you are made of come from?
	Ecosystems depend on a constant input of energy, either from the sun or chemical sources, because energy is continually lost from the system.	• How do all organisms get the energy they need to live?
	Scale and availability of resources determines the particular nature of an ecosystem.	• Why are ecosystems different from each other?
	Each species occupies a unique role within a functioning ecosystem.	• What causes biodiversity?
LS2.B Cycles of Matter and Energy Transfer in Ecosystems Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.	**KNOWLEDGE**	**SKILLS**
	Students will know:	**Students will be able to:**
	The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways.	Trace the path of a carbon, oxygen, nitrogen, or phosphorus atom into and out of the biotic world.
	At each link in the food web, some energy is stored in newly-made structures, but much is dissipated into the environment as heat.	Create a food web diagram and use it as a model to predict the effects of change across a community.
	Continual input of energy is required for the maintenance of all ecosystems.	Model the flow of energy in different types of ecosystems and the energy lost at different levels of a food chain.
LS2.C Ecosystem Dynamics, Functioning, and Resilience A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest	Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars, and releasing oxygen.	Relate the organismal processes of cellular respiration and photosynthesis to ecosystem scale dynamics such as carbon cycling and energy transfers.

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. Moreover, anthropogenic changes (induced by human activity) in the environment – including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change – can disrupt an ecosystem and threaten the survival of some species. **LS2.D Social Interaction and Group Behavior** Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. **LS4.D Biodiversity and Humans** Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. **PS3.D Energy in Chemical Processes** The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. **ETS1.B Developing Possible Solutions** When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	Age, climate, and history of disturbance affect the way that living communities build and maintain stability. Coevolution of numerous species in competitive, mutualistic, and predatory relationships leads to communities with complex system dynamics Animals compete and cooperate with others of their own species in a variety of ways that serve to increase survival. Analysis of the risks and benefits of human policies to the environment is guided by historical scientific data as well as modeling to predict future behavior. **Key Terms and Concepts** Ecosystem, community, trophic level, niche, food chain, food web, nitrogen cycle, carbon cycle, detritus, scavenger, predator, prey, parasite, symbiosis, commensalism, coevolution, hydrothermal vents, territoriality, inclusive fitness, reciprocity.	Model the effects of adding or subtracting a species from a simple ecosystem. Evaluate the impact of a natural phenomenon on an area and predict the impact on the population. Explain why some ecosystems are more productive than others. Describe a variety of factors that may impact the carrying capacity of an environment Determine from data the adaptive value of territoriality, herding, migration, or cooperative hunting within a species. Use data to analyze environmental risks and benefits associated with human activity and the use of natural resources. Use ecological principles and a variety of data sources to evaluate potential solutions to environmental problems such as air and water quality, energy management, and loss of biodiversity.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Using mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales **(**HS-LS2-1)
- Using mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales **(**HS-LS2-2)
- Constructing and revising an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions (HS-LS2-3)

- Using mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem **(**HS-LS2-4)
- Developing a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere (HS-LS2-5)
- Evaluating 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 (HS-LS2-6)
- Designing, evaluating, and refining a solution for reducing the impacts of human activities on the environment and biodiversity (HS-LS2-7)
- Evaluating the evidence for the role of group behavior on individual and species' chances to survive and reproduce (HS-LS2-8)

KEY LEARNING EVENTS AND INSTRUCTION:

- Suggested labs and performance assessments: Competition simulations, predation simulations, Kaibab Deer Case Study, Trapping Geese Case Study, population sampling labs, food web labs, bio magnification labs, Matter Cycle Board Games, Algae farms, SPONCH Tweets, invasive species case studies, human population growth analysis and impacts, Net Logo models (e.g. Wolf, Sheep, and Grass); Radix Endeavor multiplayer inquiry game.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Biology
Unit V: Ecology and Ecosystem Functioning

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
7 Weeks	• Cycling of matter • Flow of energy, energy pyramids and calculations • Populations • Community dynamics: competition, predation, symbiosis, coevolution • Biodiversity and its importance to stability in ecosystems • Human impacts: climate change, habitat disturbances, resource use, invasive species, pollution	Suggested videos: • Discovery Channel Cosmos episode "World Set Free (Climate Change and Global Warming)", • NASA Animation "A Year in the Life of Earth's CO_2" (YouTube: https://www.youtube.com/watch?v=x1SgmFa0r04), • BBC Planet Earth, "Earth" • PBS Evolution Series episode 3: "Extinction!" • PBS Evolution Series episode 4: "The Evolutionary Arms Race" Suggested game-based resources and simulations: • RadixEndeavor.org full simulation experience for students • NetLogo.org simulations http://ccl.northwestern.edu/netlogo/index.shtml

APPENDIX A

Next Generation Science Standards
Crosscutting Concepts and Science & Engineering Practices

Crosscutting Concepts of Science:	**Science & Engineering Practices:**
• Cause & Effect • Scale, Proportion, and Quantity • Systems and System Models • Energy and Matter: Flows, Cycles, and Conservation • Structure and Function • Stability and Change of Systems • Patterns	• 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

APPENDIX B

General resources:

- NJ Student Learning Standards – Science http://www.state.nj.us/education/cccs/2016/science/
- Bozeman Science – NGSS Tutorials for Teachers http://www.bozemanscience.com/next-generation-science-standards
- Biology Project http://www.biology.arizona.edu/
- HHMI BioInteractive http://www.hhmi.org/biointeractive/
- MIT Open Courseware http://ocw.mit.edu/index.htm
- NOVA Education http://www.pbs.org/wgbh/nova/education/

APPENDIX C

Sample Labs for Each Unit:

- Unit I: An Apple a Day Keeps the Doctor Away (Introduction to Experimental Design)
- Unit II: Sock-it to Mitosis
- Unit III: Pool Noodle Protein Synthesis
- Unit IV: Natural Selection of Dots
- Unit V: The Effect of Competition on Populations of *Paramecium*

Name: **Period:** **Date:**

"An Apple a Day Keeps the Doctor Away"

We have all heard this and many other similar claims throughout our lives. But how do we know if they are true?

Your Task:

Part I.

1. In small groups, discuss and develop a plan for how you could test the "An apple a day…" statement to see if it is valid.
2. In bullet or outline form, put your experiment plan onto a whiteboard. Be prepared to explain your design to the class.
3. When other groups present their ideas, take note of aspects of their plans that could be improved. By politely sharing your critique of another group's experiment you will be helping everyone to learn more about scientific inquiry.

Part II.

1. Choose a statement from the list below.
2. Design an experiment to test the validity of that claim. Explain your experimental plan in writing.
3. You will be exchanging this plan with a peer for constructive criticism.

Statements for experimental design:

- Eating chocolate causes zits.
- Shaving makes hair grow back more densely.
- Drinking coffee will stunt a child's growth.
- If you swim immediately after eating, you will get cramps.
- If you go outside when your head is wet, you'll catch a cold.
- Feed a cold, starve a fever.
- Break a mirror and you will have seven years of bad luck.
- If you blow out all the candles on your birthday cake with the first puff, you will get your wish.
- The full moon makes people restless.
- Eating carrots improves eyesight.
- If you cross your eyes too often, they will stay that way.
- Reading in dim light damages a person's eyes.

Adapted from Biology Inquiries by Martin Shields (2008)

Name: **Period:** **Date:**

Sock-it to Mitosis

Part of the cell theory states that all cells are derived from preexisting cells. When you get a cut, new cells must be formed to replace the damaged or missing cells. It is important that the new cells contain the exact genetic information as the cells from which they arise. Therefore, genetic information must be copied and then the nucleus must break down in order for the information to be distributed evenly. The process of the nucleus dividing up the genetic material is called MITOSIS.

The following activity will take you through the stages of mitosis using socks and rope to simulate these stages. At this point, you should choose a narrator from your group. Your narrator will be responsible for reading off the instructions while the other members perform the actions for each stage.

Purpose: To visualize the stages of mitosis by physically simulating nuclear division using socks and rope.

Materials:

- 4 pairs of long socks (obviously different)
- 2 long pieces of rope
- 10 short pieces of rope

Pre-activity questions: Answer these on the pre-activity worksheet before you begin this activity.

Procedure (Narrator): The narrator should read out the stage, let the "actors" act out the stage. *THEN* ask the question if a question follows. The answers to the questions should be given in spoken responses, *NOT* written. Do not stop the activity to write answers down. *BUT* do not move on to the next step until the question has been answered.

1. Make a large circle out of the 2 long pieces of rope, with the ends of the rope meeting on the long side of the lab table. This circle represents the cell membrane.

2. Create a small circle inside the larger circle, using the short pieces of rope. Make sure that the circle is complete.

    a. What does this circle represent?
    b. Why are we using two pieces of rope instead of one?

3. For each pair of socks, put one completely inside the other so that only one sock is visible.

4. Place all of the socks inside the smaller circle on your table.

a. What stage of the cell cycle is represented by this arrangement?
b. What does the pile of socks in the center represent?

5. For each sock, remove the sock from inside. Put all of the socks back in a pile in the middle circle.
    a. What did taking the sock out of the other sock represent?
    b. What phase of the cell cycle is being represented?

6. You should now have a "cell" with "replicated DNA" and you are ready for mitosis.

7. Remove every other short rope from the middle circle. The nuclear envelope is now breaking down.

    a. What phase does this arrangement symbolize?
    b. How do you know?

8. Hold the two socks side by side and tie them together by forming a loose knot in the middle. The socks should be facing the same direction. Place all of the socks back in the middle of the smaller circle.

    a. What does each pair of socks represent now that the knot has been tied?
    b. What does EACH sock represent after the knot has been tied?
    c. What does the knot in the center represent?

9. Spread out the sock pairs so that they are distinguishable from each other but in no particular order.

10. Remove the rest of the short ropes from the inner circle.

11. Partners should move to opposite sides of the table. (Everyone should be on the short sides of the lab table.)

12. When at opposite sides of the table, each person grab a chromosome by the centromere and move the chromosomes to a straight line across the center of the "cell".

    a. What stage does this arrangement represent?
    b. What do the arms of the students represent?

13. Each opposite partner, grab a sock from one side of the knot. The other partner should grab the sock that is tied to that sock, at the knot. This should be set up so that if each partner pulls, the socks will come untied and each partner will have a sock from the pair.

14. Each partner should remain at opposite ends of the table and pull individual socks toward opposite ends of the table or "cell". Each partner should pull the socks along the surface of the table (the socks should make a V shape as you pull because you are holding it in the center).

    a. What stage does this represent?

15. Put the socks in a ball at opposite ends of the table or "cell".
    a. This represents the chromosomes returning to what?

16. Curve the ends of the long ropes in slightly to simulate the pinching in of the cell membrane.
    a. What is this pinched area called?

17. Use the short ropes to start forming a small circle around the sock piles.
    a. What phase of mitosis does this arrangement represent?

18. Separate the long ropes where they are curved inward and connect the ends to form cell membranes around the new cells.
    a. What stage was just represented by the closing off of the new cell membranes?
    b. What phase are the new cells in now?

19. Repeat these stages without reading the steps.

20. This will be timed eventually for a race, you will not be able to read the steps. You will also be assessed as a group by your teacher!

Post-activity questions: Find these attached to your pre-activity worksheet. Answer these at the completion of this activity.

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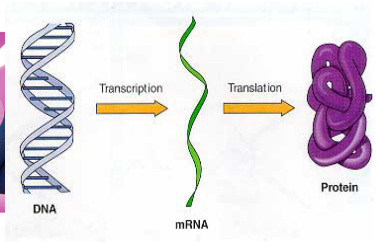
Pool Noodle Protein Synthesis

Directions: This activity represents Protein Synthesis (DNA → RNA → Protein) and is acted out like a play, using props. You will get one role in the play and you will act out that role for the duration of the activity. Circle your role below when you are assigned a role.



Props:
Pool noodles: 20 different amino acids
Lab stations: Ribosomes
Chalkboard with DNA sequences written: Nucleus
Classroom: Cytoplasm
Paper tape: mRNA
Students: Ribosomes, RNA polymerase, or tRNAs

Team Roles:
Narrator: Teacher
RNA Polymerase: Performs **transcription** by transcribing DNA to mRNA in the nucleus.
Ribosome site 1: Begins **translation** by reading the three-letter codons aloud in order.
Ribosome site 2: Bonds amino acids together in the growing protein.
tRNAs: Your part is to obtain one of the 20 amino acids you are assigned, and hold onto it with your left hand. In your right hand, you must hold your anticodon. Once your codon is called, you should match up with it and bring your amino acid to the ribosome. You may be assigned a dual role.

Instructions:

1. *Narrator:* "RNA polymerase (the mRNA) transcribes the DNA sequence into mRNA." *While others watch and proofread, the RNA Polymerase matches up complementary RNA with the DNA sequence using a marker and paper.*
2. *Narrator:* "The mRNA is then transported from the nucleus to the ribosome. DNA remains in the nucleus."
3. *Each tRNA wears a bib with an anticodon sequence.*
4. *Narrator:* "Each tRNA must grab an amino acid that corresponds to their anticodon on their bib. Then, each tRNA must determine which codon matches with their anticodon. The codon will be "read" out loud by the ribosome. When the codon is read, the amino acid with the corresponding anticodon must arrive at the ribosome with their amino acid in hand."
5. *Ribosome 1 reads the codons in three-letter sequences once. tRNA's must pay attention carefully. Once a codon is read, the tRNA with the complementary anticodon must search for their amino acid. Once it is found, the tRNA lines up and puts one hand on the mRNA and holds out the amino acid with the other hand. Once the second codon is read, a second tRNA performs the same action.*
6. *Ribosome 2 then bonds together the two amino acids. Only two tRNAs can fit in the Ribosome at one time, so once a third tRNA arrives, the first tRNA lets go of the amino acid and leaves the ribosome.*
7. *Repeat this process until the entire mRNA is translated into a protein chain.*
8. Once the first run through is completed, it will be repeated as a race. Remember, tRNA's cannot search for their amino acid until their corresponding codon is called. Make sure

Name: **Period:** **Date:**

you are paying attention carefully! More DNA sequences will be added to the nucleus as additional races. *The team to win the most races wins!*

Sequences

Vasopressin:
TACACGATGAAGGTTTTAACGGGTGCTCCTATC

Oxytocin:
TACACGATGTAGGTTTTAACGGGTGATCCTATC

Post-Lab Questions: Pool Noodle Protein Synthesis Activity

1) Record the two DNA sequences for oxytocin and vasopressin here:

_____
_____
_____

2) Record the mRNA sequences that were made for both oxytocin and vasopressin here:

_____
_____
_____

3) Record the amino acid sequences for both of the proteins we made, and compare them. How many amino acids differ?

_____
_____
_____
_____
_____

4) Explain how a difference in DNA results in a difference in the protein:

_____
_____
_____
_____
_____
_____

5) Finally, explain how a protein's structure (amino acid sequence) determines its function:

_____
_____
_____
_____
_____
_____
_____

Natural Selection of Dots

Introduction

All populations of organisms have a variety of phenotypes. All populations of organisms struggle to survive- competing for food, reacting to the climate, and attempting to avoid predators. Competition, climate, and predation are just a few of the factors by which the environment selects who survives and who does not. This is called natural selection—nature (also known as the environment) selects who survives. The processes of genetics assure that the survivors pass their traits on to their own offspring. Over time, nature affects the genetics of the entire population by favoring some alleles and eliminating others. The change in genetics of a population is called evolution. The changing phenotypes that we see over the generations are just a reflection of this change in genetics.

In this exercise, we will imitate the process of natural selection. Our organism is paper chips. The chip population contains a variety of alleles for color, resulting in 10 different colored phenotypes. These chips live in a two-dimensional cloth environment. They are preyed upon by sophomores. How does predation affect the survival of chips? Are some phenotypes more likely to survive than others? Are all chips equally adapted to all possible environments?

Supplies:

- 1 yard of colored cloth
- 100 paper chips, 10 each of 10 colors
- 2 beakers

Procedure

1. Spread out the fabric "habitat" on the tabletop.

2. Count out 10 chips of each of the 10 colors for a total of 100 as your initial population. Mix your colored chips together in a BIRTH beaker.

3. Appoint one person as the prey (chip) **distributor**. That person should spread the chips out randomly over the entire fabric, making sure the chips do not stick together. The other members of the group should have their backs turned during this procedure.

4. The **predators** (other group members) should turn around one by one and pick off the first chip they see. Put these chips into the DEATH beaker. (do not lose them.) After the first person picks a chip, the second person can turn around, take a chip, and then turn away. Go around the table taking turns. Pick off one chip (the first one you spot) per turn. Face away from the table whenever it is not your turn. You can do this part of the activity very quickly once you get your rhythm down. STOP when 75 chips have been taken. The distributor can keep track of this.

5. Carefully remove **survivors** (remaining 25 chips). There must be 25 chips, or something is wrong. If anything hits the ground, pick it up.

6. Group the **survivors** according to color. Count and record these numbers in the data table, under the column for each color. You are counting the survivors remaining on the cloth, not the chips you "killed." These survivors are able to reproduce asexually, producing three babies each. Counting the survivor, this makes four chips for the next generation. "Generate" the next row of your table by taking each number, multiplying it by four, and putting the result in the row labeled generation II. (If there are zero chips, 0 x 4 = 0. Note that you multiply by four since the original chip stays alive, and its three babies stay alive.)

7. Referring to your table for the correct numbers of each color, now refill your BIRTH beaker with 100 colored chips. (Get the babies from the supply of spare chips in your death beaker or from the teacher if necessary) You now have 100 chips in your mixing beaker, but they may not be the exact same numbers *of each color* as you had at the start of the lab.

8. Stir your BIRTH beaker and redistribute the new set of 100 colored chips back on the fabric. Prey upon them, one by one, until only 25 are left alive. Fill out the next row in your data table, and then multiply by four to get the row beneath that.

9. Repeat the entire process, making a total of three generations of chips being preyed upon. At the end of the third round of predation, you can calculate the numbers of each color that would be born, but you do not need to actually count them out. Just fill in the last row of the table.

10. Look at the cloths and the data that the other groups obtained during this lab so that you can compare them to your results.

11. Remove all chips and sort them by color. Put each color back into the proper container.

Natural Selection of Dots Data Sheet Name_____

Purpose: To simulate the evolution of an animal population through the process of natural selection.

Background: In this exercise you will see what an important influence the environment is on natural selection. The members of your group will be the predators and your prey will be colored chips of paper. Only the surviving chips will be able to reproduce and leave offspring behind. You may be surprised at some of the changes in the population of the prey species.

Describe your cloth's design and its major colors. _____
_____

	Numbers of Chips, by color										Total
Write in color names here —>											
Generation I	10	10	10	10	10	10	10	10	10	10	100
After first predation											25
Generation II											100
After second predation											25
Generation III											100
After third predation											25
Generation IV											100

Make a graph from the above data using graph paper or Microsoft Excel. Have the Generation number along the horizontal axis (bottom) and the number chips of each color along the vertical axis. Be sure to use a different color for each bar.

Analysis Questions

1. Please attach your graph to the answers to the analysis questions.

2. Describe your cloth's design and its major colors.

3. Study your survivor populations. Describe any changes that occurred in the distribution of colors within the population as the generations progressed.

4. What adaptation did the surviving chips have that the other chips did not?

5. What caused the shift in color distribution of your population of chips? Explain what role the environment (the cloth) as well as the predators played in this.

6. Darwin and Wallace said that organisms possessing an advantageous trait are more likely to survive and pass that trait on to their offspring. Explain how this lab demonstrates that idea.

7. Go take a look at the cloth used all the other lab groups. How did the cloth affect survival at that table? How are your data similar and different from the other groups? How do your cloths compare? Be sure to consider the complexity, number of colors, and scale of the design on the cloth.

8. If these paper chips were really a species of living organisms, how would new traits such as a new color or new shape arise in the population in the first place?

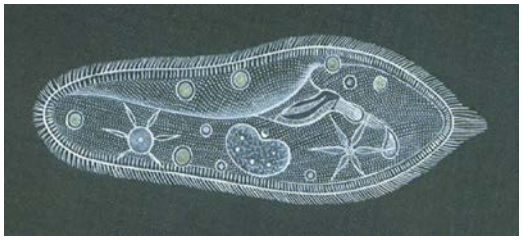
9. What represented natural selection in this lab? Define natural selection.

10. Name a factor other than color that may have influenced which chips survived.

11. Many birds prey upon insects. Explain four adaptations (traits), either physical or behavioral, that would help insects survive this predation. DO NOT include camouflage.

12. Differential survival, as we saw in this lab, affects the composition of future generations. What factor other than differential survival can affect the composition of future generations?

The Effect of Competition on Populations of *Paramecium*



Paramecium aurelia

Paramecium caudatum

How to get there: http://glencoe.mcgraw-hill.com/sites/dl/free/0078757134/383928/BL_04.html

Instructions: This lab has instructions on the left hand side and also contains pages to enter data and questions. Record your data in the table and answer the journal questions. Make a graph based on the data. You may use Excel, or make it by hand on graphing paper.

Data Table				
	P. 38urelia grown alone, cells/mL	*P. caudatum* grown alone, cells/mL	*P. 38urelia* grown in mixed culture, cells/ mL	*P caudatum* grown in mixed culture, cells/mL
Day 0				
Day 2				
Day 4				
Day 6				
Day 8				
Day 10				
Day 12				
Day 14				
Day 16				

Journal
1. Do these two species of *Paramecium* prey on each other? Explain how you know this.
2. Make a hypothesis about how you think the two species of Paramecium will grow alone and how they will grow when they are grown together (mixed culture).
3. A ***carrying capacity*** can be defined as the largest number of individuals of a particular species that a particular environment can support. On what day did the *Paramecium caudatum* population reach the carrying capacity of the environment when it was grown alone?
4. On what day did the *Paramecium aurelia* population reach the **carrying capacity** of the environment when it was grown alone?
5. Explain the differences in the population growth patterns of the two *Paramecium* species. What does this tell you about how *Paramecium aurelia* uses available resources?
6. Describe what happened when the *Paramecium* populations were mixed in the same test tube and explain how this demonstrates that no two species can occupy the same niche. What was causing the trends in population size of each species?
7. Make a graph that shows the growth rates of each *Paramecium* species grown alone and in mixed cultures (line graph, make each line a different color and include a key, include title, axes labels, and a proper scale!). ***The independent variable goes on the X-axis, and the dependent variable goes on the Y-axis!***

Adapted from https://www.biologycorner.com/worksheets/virtual_lab_population.html