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MISSISSIPPI DEPARTMENT OF EDUCATION

Ensuring a bright future for every child

2018 Mississippi College- and Career-Readiness Standards for Science

Effective Date: 2018-2019 School Year

2018 Mississippi College- and Career-Readiness Standards for Science

Carey M. Wright, Ed.D., State Superintendent of Education

Kim S. Benton, Ed.D., Chief Academic Officer

Jean Massey, Executive Director, Office of Secondary Education

Nathan Oakley, Ph.D., Executive Director, Office of Elementary Education and Reading

Wendy Clemons, Executive Director, Office of Professional Development

Tenette Smith, Ed.D., Bureau Director, Office of Elementary Education and Reading

Marla Davis, Ph.D., NBCT, Bureau Director, Office of Secondary Education

Jackie Sampsell, Ed.D., Science Specialist, Office of Secondary Education

Mississippi Department of Education
Post Office Box 771
Jackson, Mississippi
39205-0771

Office of Elementary Education and Reading
Office of Secondary Education
601-359-2586
www.mde.k12.ms.us/ESE

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Acknowledgements

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SCIENCE WRITING TASK FORCE COMMITTEE MEMBERS (2015-2017)

Jennifer Bennett	Calhoun County School District
Tim Bermond	Clinton Public School District
Shani Bourn	Hancock County School District
Tammie Bright	Yazoo County School District
Kelly Cannan	Pascagoula-Gautier School District
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Peggy Carlisle	Jackson Public Schools
Tonya Carter	Sunflower County Consolidated School District
Renee Clary, Ph.D.	Mississippi State University Department of Geosciences
Gail Davis	Lafayette County Schools
Charronda Denis	Pascagoula-Gautier School District
Deborah Duncan	Neshoba County School District (Retired)
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Kevin Gaylor	Jackson Public School District
Darcie Graham	University of Southern Mississippi Gulf Coast Research Lab
Tia Green	Tupelo Public School District
Brandi Herrington	Starkville Oktibbeha Consolidated School District
Jennifer Hood	Amory School District
Ann Huber	Mississippi Delta Community College/MSTA President
Whitney Jackson	University of Mississippi Center for Mathematics and Science Education
Deborah Jones	Lafayette County Schools/Northwest Community College
Tiffany Jones-Fisher	Mississippi Gulf Coast Community College
Myra Kinchen, Ed.D.	Clinton Public School District
Melissa Levy	Madison County School District
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Sharman Lumpkin	Pearl River County School District
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Angela McDaniel	Pearl Public School District
Crystina Moran	Biloxi Public School District
Jennifer Pannell	Union County School District
Maureen Pollitz	Picayune School District
Linda Posey	Meridian Public School District
Terry Rose	Stone County School District
Leslie Salter	Pascagoula-Gautier School District
Betsy Sullivan, Ph.D.	Madison County School District
Heather Sullivan	Mississippi Museum of Natural Science
Mary Swindell	Meridian Public School District
Kimberly Taylor-Gathings	Columbus Municipal School District

Jessica Tegt, Ph.D.	Mississippi State University Dept. of Wildlife, Fisheries, and Aquaculture/Extension
David Teske	Louisville Public Schools (Retired)
Julie Viguerie	Lamar County School District
Tina Wagner	Mississippi School for Math and Science
Ryan Walker, Ph.D.	Mississippi State University Dept. of Curriculum, Instruction, and Special Education
Tiffany Webb	Gulfport School District
Kristy Wheat	Pass Christian School District
Veronica Wylie	Copiah County School District

FINAL REVIEW COMMITTEE (March 2017)

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Cindy Betancourt	Petal Public School District
Tammie Bright	Yazoo County School District
Brandon Cline	Rankin County School District
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Kasey Edwards	Neshoba County School District
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Tia Green	Tupelo Public School District
Courtney Harris	Clinton Public School District
Jennifer Hite	Pearl Public School District
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April Pounders	South Tippah School District
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Jessica Satcher	Lauderdale County School District
Andy Scoggin	Petal Public School District
Fonya Scott	Lauderdale County School District
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Kelle Sumrall	Lafayette County School District
Jane Thompson	Gulfport School District
Jason Woodcock	Clinton Public School District
Kristy Wheat	Pass Christian School District

COORDINATION AND EDITING (2015 – 2017)

Gabrielle Barrientos	Research and Curriculum Unit, Mississippi State University
Marla Davis, Ph.D.	Mississippi Department of Education
Anne Hierholzer-Lang	Research and Curriculum Unit, Mississippi State University

Tanjanikia McKinney	University of Mississippi/Mississippi Department of Education
Cindy Ming	Research and Curriculum Unit, Mississippi State University
Holly Holladay	Research and Curriculum Unit, Mississippi State University
Kenny Langley	Research and Curriculum Unit, Mississippi State University
Jean Massey	Mississippi Department of Education
Roslyn Miller	Research and Curriculum Unit, Mississippi State University
Nathan Oakley, Ph.D.	Mississippi Department of Education
Myra Pannell	Research and Curriculum Unit, Mississippi State University
Jackie Sampsell, Ed.D.	Mississippi Department of Education
Denise Sibley	Research and Curriculum Unit, Mississippi State University
Jolanda Young	Research and Curriculum Unit, Mississippi State University

Introduction

Mission Statement

The Mississippi Department of Education is dedicated to student success, which includes improving student achievement in science, equipping citizens to solve complex problems, and establishing fluent communication skills within a technological environment. The Mississippi College- and Career-Readiness Standards provide a consistent, clear understanding of what students are expected to know and be able to do by the end of each grade level or course. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that students need for success in college and careers and allowing students to compete in the global economy.

Purpose

In an effort to closely align instruction for students who are progressing toward postsecondary study and the workforce, the *2018 Mississippi College- and Career-Readiness Standards for Science* includes grade- and course-specific standards for K-12 science.

This document is designed to provide K-12 science teachers with a basis for curriculum development. In order to prepare students for careers and college, it outlines what knowledge students should obtain, and the types of skills students must master upon successful completion of each grade level. The *2018 Mississippi College- and Career-Readiness Standards (MS CCRS) for Science* replaces the *2010 Mississippi Science Framework*. These new standards reflect national expectations while focusing on postsecondary success, but they are unique to Mississippi in addressing the needs of our students and teachers. The standards' content centers around three basic content strands of science: life science, physical science, and Earth and space science. Instruction in these areas is designed for a greater balance between content and process. Teachers are encouraged to transfer more ownership of the learning process to students, who can then direct their own learning and develop a deeper understanding of science and engineering practices, critical analysis, and knowledge. Doing so will produce students that will become more capable, independent, and scientifically literate adults.

Implementation

The *2018 Mississippi College- and Career-Readiness Standards (MS CCRS) for Science* will be implemented during the 2018-2019 school year.

2018 Mississippi College- and Career-Readiness Standards for Science Overview

Research and Background Information

In today's modern world and complex society, our students are required to possess sufficient knowledge of science and engineering to become vigilant consumers of scientific and technological information. To meet the growing challenges facing our future workforce, the National Research Council (NRC) published a research-based report on teaching and learning science in a 2012 document titled *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012). This document proposes a new approach to K-12 science education through the integration of science and engineering practices (SEPs), crosscutting concepts, disciplinary core ideas, and engineering design within the context of science instruction.

Core Elements in the Use and Design of the *MS CCRS for Science*

The *MS CCRS for Science* are goals that reflect what a student should know and be able to do. This document does not dictate a manner or methods of teaching. The standards in this document are not sequenced for instruction and do not prescribe classroom activities, materials, or instruction strategies. These standards are end-of year expectations for each grade or course. The standards are intended to drive relevant and rigorous instruction that emphasizes student mastery of both disciplinary core ideas (concepts) and application of science and engineering practices (skills) to support student readiness for citizenship, college, and careers.

The *MS CCRS for Science* document was built by adapting and extending information from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012) and combining with Mississippi's previous science framework process strands (i.e., science as inquiry, unifying concepts and processes, science and technology, science in personal and social perspectives, and the history and nature of science). These concepts connect information across the science content strands (i.e., life science, physical science, and Earth and space science) with the disciplinary core ideas (e.g., ecology and interdependence, motions, forces, and energy, Earth systems and cycles) and are essential to both scientists and engineers because they identify common properties and processes found in practice.

The core elements are integrated across standards and performance objectives in each grade and course. A brief description of each core element is presented below.

1. Nature of Science: Science and Engineering Practices (SEPs) replaced the Inquiry Strand included in the *2010 Mississippi Science Framework*. Beyond integration within the standards, these practices must be mastered by students to produce a more scientifically literate citizenry and to develop students that are more excited about STEM (Science, Technology, Engineering, and Mathematics) topics and careers. Inquiry verbs, along with the SEPs, are woven throughout the standards, especially in the performance objectives. Each has a deliberate placement to indicate the depth of understanding expected of students.

   The practices describe the behaviors that scientists engage in as they investigate and build models and theories about the natural world. They also describe the key set of engineering practices that engineers use as they design and build models and systems. These practices work together (overlap and interconnect) and are not separated in the study and investigation of science concepts. For example, the practice of *mathematical and computational thinking* may include some aspects of *analyzing and interpreting data*. The data often come from *planning and carrying out an investigation*. The writing task force for the *MS CCRS for Science* incorporated this language into the performance objectives to emphasize the importance of a student-centered science classroom and not a teacher-centered classroom. A list of these eight practices is listed below.

a. **Ask Questions (science) and Define Problems (engineering)**
b. **Develop and Use Models**
c. **Plan and Conduct Investigations**
d. **Analyze and Interpret Data**
e. **Use Mathematical and Computational Thinking**
f. **Construct Explanations (science) and Design Solutions (engineering)**
g. **Engage in Scientific Argument from Evidence**
h. **Obtain, Evaluate, and Communicate Information**

2. Crosscutting concepts: These seven, binding concepts were adopted directly from the National Research Council's *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (2012) and should be woven into instruction for every grade and course. Crosscutting concepts are designed to help students see the unity of the sciences. Students often are confused when they study ecosystems for three weeks, then weather for two weeks, and finally motion and forces for several weeks. A concept is crosscutting if it communicates a scientific way of thinking about a subject and it applies to many different disciplines of science and engineering. Crosscutting concepts are sometimes called "the ties that bind." The seven concepts are listed below.

    a. **Patterns**
    b. **Cause and effect: Mechanism and explanation**
    c. **Scale, proportion, and quantity**
    d. **Systems and system models**
    e. **Energy and matter: Flows, cycles, and conservation**
    f. **Structure and function**
    g. **Stability and change**

3. Technology: If Mississippi students are to compete on a global stage and exit high school prepared for college, career, and life, technology should be used in the classroom in a way that suits 21st-century learners and reflects the modern workplace. Technology is essential in teaching and learning of science; it influences and enhances students' learning. Flexible access, customized delivery, and increased convenience for the user are core tenets. K-12 learners have fundamentally changed over the past few decades, and our classrooms should adapt to accommodate them. Dr. Ruben Puentedura's SAMR (Substitution, Augmentation, Modification, and Redefinition) model is a resource that can be considered by teachers, administrators, and technology staff as they integrate meaningful and appropriate digital learning experiences into the classroom. At the basic level, technology enhances instruction.

4. Science and society: This core element assures exploration of science's impacts on society and the feedback loop that must be cultivated and sustained to continue improvement of systems.

5. History of science: Because most modern-day scientific advancement derives from past discoveries, it is essential that students understand the breakthroughs that make today's work possible.

6. Engineering design process (EDP) is the method of devising a system, component, or process to meet desired needs. Engineering standards are represented in some performance objectives with grade-banded, specific wording that prompts educators to approach learning and exploration using the engineering process. These performance objectives are marked with an *. It is important to

note that the EDP is flexible. Most students will approach the process in various ways. The EDP is also a cycle—there is no official start or end point. Students can begin at any step, focus on just one step, move back and forth between steps, or repeat the cycle. Professional development and teacher resources will be developed for Mississippi teachers as EDP is incorporated into Mississippi standards.

Students should be provided a safe environment for failure without consequence, which is one of the most powerful drivers in learning. Providing many opportunities for students to fail, learn, and try again, with appropriate levels of support, fosters a deeper level of understanding and greater student interest and engagement.

Other Important Core Elements

Mathematics is integrated throughout the science standards document because it is essential to the scientific process, requiring students to quantify, analyze, and present results. Students must be familiar with data analysis, critical thinking, and recording their own data; students must organize and analyze it before presenting their findings. Analysis of scientific studies and publications from a quantitative perspective is also very important.

English/language arts skills are also integrated into the science standards. Students will be required to read informational text for understanding as well as process and critique information. Students must be able to articulate a critical point of view using proper terminology. In addition, the K-4 science curriculum should be increasingly tied to language arts to lay the foundation for students to have access to science before fifth grade.

Content Strands and Disciplinary Core Ideas

Science (and engineering) fields can be divided into three content-strand domains based on relative content presented in strands, extending from kindergarten to eighth grade. Grouping content in this way allows for vertical alignment of competencies and objectives to better organize content distribution. Content strands are not included in the Grades 9-12 course organization, which allows for a more logical, sequential placement and flow of content. Content strands are subdivided into 10 disciplinary core ideas in which standards and performance objectives for science content can be placed in grades K-8.

K-8 content strands with the 10 disciplinary core ideas include:

Life Science

1. Hierarchical Organization
2. Reproduction and Heredity
3. Ecology and Interdependence
4. Adaptations and Diversity

Physical Science

5. Organization of Matter and Chemical Interactions
6. Motions, Forces, and Energy

Earth and Space Science

7. Earth’s Structure and History
8. Earth and the Universe
9. Earth Systems and Cycles
10. Earth’s Resources

Structure of the Standards Document

The organization and structure of this standards document are as follows:

- Grade-band overview: An overview that describes the general content and themes for the grade-level band or the high school courses. Outputs and outcomes are provided along with examples of, and references to, science and engineering practices and connecting concepts.

- Grade-level or course overview: An overview that describes the specific content and themes for each grade level and/or high school course. The K-8 standards are presented with each grade focused on a grade-level theme. High school courses provide an overview of the major ideas and strategies to use when planning instruction for the course.

- Content strand: Domains into which science fields can be divided based on relative content extending from kindergarten to eighth grade. In grades K through 8, the content strands are organized into three distinct areas: (1) life science, (2) physical science, and (3) Earth and space science. For the Grade 9-12 courses, the content areas are organized around the core ideas of each course.

- Disciplinary core ideas: Subdivision of the main content strands providing recurring ideas from the three content strands. The core ideas are the key organizing principles for the development of learning units. The K-8 vertical alignment is designed in a spiral arrangement, which places emphasis on one of the three content strands in each grade level. All content strands will be found in each grade level, but all disciplinary core ideas will not be found in every grade level in K-8 due to the spiral arrangement of content.

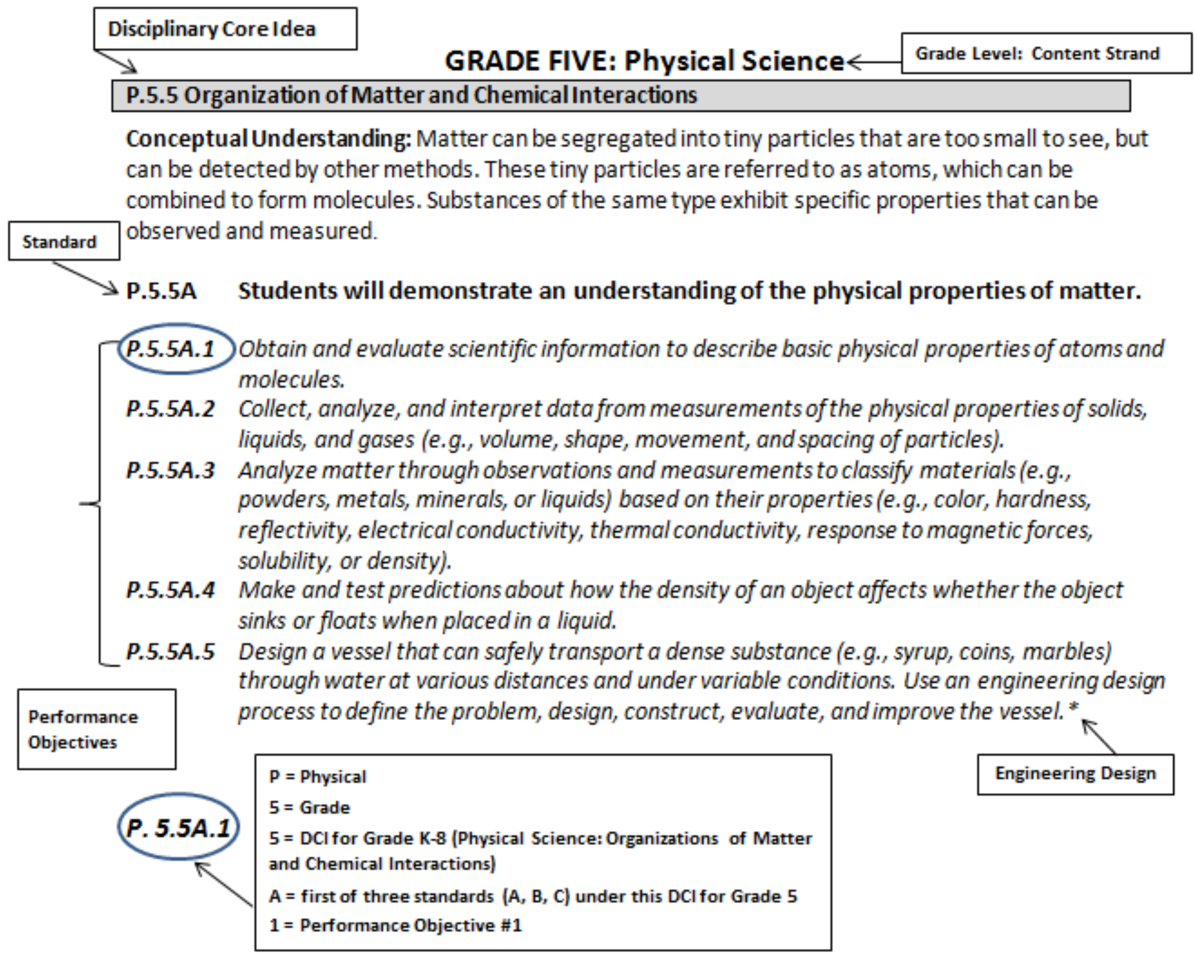
- Conceptual understanding: Statements of the core ideas for which student should demonstrate an understanding. Some grade level and/or course topics include more than one conceptual understanding with each guiding the intent of the standards.

- Content standards: Written below each disciplinary core ideas and conceptual understanding, the standards are a general statement of what students should know and be able to do because of instruction.

- Performance objectives: Detailed statements of content and skills to be mastered by the students. Performance objectives are specific statements of what students know and can do because of the science instruction at that level. These statements contain SEP and inquiry verb language.

Standards will appear in the following format:

Grade-Band Overview
Grade Level Theme (K-8)
Grade Level (K-8) or Course Overview (9-12)
Grade Level: Content Strand (K-8); Course Name (9-12)
    Disciplinary Core Idea (DCI)
    Conceptual Understanding
    Standard
    Performance Objectives



Safety in the Science Classroom

The National Science Teachers Association (NSTA) encourages K–12 school leaders and teachers to promote and support the use of science activities in science instruction and work to avoid and reduce injury. NSTA provides the following guidelines for school leaders and teachers to develop safety programs that include the effective management of chemicals, implement safety training for teachers and others, and create school environments that are as safe as possible (NSTA 2013).

1) National Science Teacher Association's *Safety in the Science Classroom*, accessible at http://www.nsta.org/docs/SafetyInTheScienceClassroom.pdf.
2) An extensive list of safety resources is available at http://www.nsta.org/safety/.

Support Documents and Resources

The MDE will develop support documents after these standards have been approved by the State Board of Education. Local districts, schools, and teachers may use these documents to construct standards-based science curriculum, allowing them to customize content to fit their students' needs and match available instructional materials. The support documents will include suggested resources, instructional strategies, essential knowledge, and detailed information about the core elements (e.g., SEPs, crosscutting concepts).

Professional development efforts will be aligned with the standards and delivered in accord with teacher resources to help expand expertise in delivering student-centered lessons (e.g., inquiry-based learning, 5-E instructional models, or other best practices in STEM teaching). The most successful national models and programs will be referenced for a capacity-building effort that can develop a more effective culture of science education in Mississippi.

Investigate, Apply, and Understand

It is important that the pedagogical paradigm of Mississippi's science classroom reflects the nature of the content being learned. The essence of science is natural to children and includes discovery, observation, questioning, design, testing, failure, iteration, and hands-on application. Research-based approaches such as inquiry-based (IB), project-based, and discovery learning are all pedagogical pathways that make sense, especially in the science classroom. Mississippi's science teachers are encouraged to embrace the growth mindset and constantly seek to upgrade classroom approaches by experimenting and adopting methods that excite students to learn and become functional, autonomous learners and contributors. Students should be provided increased maneuverability in the classroom to formulate their own ideas to investigate and understand the scientific and engineering design processes.

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GRADES 9-12 OVERVIEW

The high school curriculum provides essential preparation for all students in Grades 9-12. This experience should promote the development of adequate scientific knowledge to allow students to make informed, critical choices and to succeed in both the workplace and in postsecondary courses.

Content standards are integrated with scientific and engineering practices (SEPs), cross-cutting concepts, and the use of technology to connect information gathered through scientific investigations with real-world applications and engineering solutions to human problems. The nature of science and historical perspectives are critical to understanding the foundation and processes of science, regardless of the scientific discipline.

The eight SEPs should not be considered a stand-alone set of practices, as previously presented, but rather incorporated throughout the set of content objectives. The SEPs are designed so that students may develop skills and apply knowledge to solve real-life problems. While presented as distinct skill sets, the eight practices intentionally overlap and interconnect as students explore the science concepts.

The core science content utilizes hands-on classroom instruction to reinforce the seven crosscutting concepts (i.e., patterns; cause and effect; scale, portion, and quantity; systems and system models; energy and matter; structure and function; and stability and change).

The National Academies' (2012) research-based findings state that "the actual doing of science or engineering can pique students' curiosity, capture their interest and motivate their continued study…" (p. 42). Science curricula should actively engage students in learning through scientific investigations. At least 30% of the course should be dedicated to laboratory experiences, including, but not limited to:

- field studies and field trips
- manipulatives and model
- guided experimentation
- student independent research and/or science fair
- computer-based simulations
- case studies

Technology plays multiple roles in content mastery. It encompasses students' awareness of current technology applications, the use of technology in data collection, and its use by teachers and students in content delivery.

Students need to be supplied with the appropriate materials and equipment necessary to conduct scientific investigations. Student safety and safe practices are primary concerns. For this reason, teachers should adhere to the National Science Teachers Association (NSTA) safety recommendations, which can be accessed at http://www.nsta.org/docs/SafetyInTheScienceClassroom.pdf.

The Engineering Design Process (EDP) is a step-by-step method of devising a system, component, or process to meet desired needs. This is similar to the "scientific method" which is taught to young scientists. However, the EDP is a flexible process. Students can begin at any step, focus on just one step, move back and forth between steps, or repeat the cycle. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.** Professional development and teacher resources will be developed for teachers as EDP is incorporated into Mississippi standards.

Each high school course contains the "Overarching SEPs for Inquiry Extension of Labs" that provides guidance for scientific investigations in all courses.

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

BIOLOGY

Biology, **a one-credit course**, is a laboratory-based course that is designed to build a life science foundation emphasizing patterns, processes, and interactions among organisms. Students are expected to master conceptual understandings based on both individual investigations and the investigations conducted by others. Individual learning experiences are used to support claims and engage in evidence-based arguments. In this way, students explore the organization of life; the interdependence between organisms and their environment; the chemical composition of life; the role of DNA, RNA, and protein in cellular structure and function; inheritance; and evolution. Local resources coupled with external resources, including evidence-based literature, will be used to extend and increase the complexity of these core ideas.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. The recommendation is that students should be actively engaged in inquiry activities, lab experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Biology

BIO.1 Cells as a System

Conceptual Understanding: Biologists have determined that organisms share unique characteristics that differentiate them from non-living things. Organisms range from very simple to extremely complex.

BIO.1A Students will demonstrate an understanding of the characteristics of life and biological organization.

BIO.1A.1 *Develop criteria to differentiate between living and non-living things.*

BIO.1A.2 *Describe the tenets of cell theory and the contributions of Schwann, Hooke, Schleiden, and Virchow.*

BIO.1A.3 *Using specific examples, explain how cells can be organized into complex tissues, organs, and organ systems in multicellular organisms.*

BIO.1A.4 *Use evidence from current scientific literature to support whether a virus is living or non-living.*

Conceptual Understanding: Organisms are composed of four primary macromolecules: carbohydrates, lipids, proteins, and nucleic acids. Metabolism is the sum of all chemical reactions between molecules within cells. Cells continuously utilize materials obtained from the environment and the breakdown of other macromolecules to synthesize their own large macromolecules for cellular structures and functions. These metabolic reactions require enzymes for catalysis.

BIO.1B Students will analyze the structure and function of the macromolecules that make up cells.

BIO.1B.1 *Develop and use models to compare and contrast the structure and function of carbohydrates, lipids, proteins, and nucleic acids (DNA and RNA) in organisms.*

BIO.1B.2 *Design and conduct an experiment to determine how enzymes react given various environmental conditions (i.e., pH, temperature, and concentration). Analyze, interpret, graph, and present data to explain how those changing conditions affect the enzyme activity and the rate of the reactions that take place in biological organisms.*

Conceptual Understanding: Cells are the basic units of all organisms, both prokaryotes and eukaryotes. Prokaryotic and eukaryotic cells differ in key structural features, but both can perform all functions necessary for life.

BIO.1C Students will relate the diversity of organelles to a variety of specialized cellular functions.

BIO.1C.1 *Develop and use models to explore how specialized structures within cells (e.g., nucleus, cytoskeleton, endoplasmic reticulum, ribosomes, Golgi apparatus, lysosomes, mitochondria, chloroplast, centrosomes, and vacuoles) interact to carry out the functions necessary for organism survival.*

BIO.1C.2 *Investigate to compare and contrast prokaryotic cells and eukaryotic cells, and plant, animal, and fungal cells.*

BIO.1C.3 *Contrast the structure of viruses with that of cells, and explain why viruses must use living cells to reproduce.*

Conceptual Understanding: The structure of the cell membrane allows it to be a selectively permeable barrier and maintain homeostasis. Substances that enter or exit the cell must do so via the cell membrane. This transport across the membrane may occur through a variety of mechanisms, including simple diffusion, facilitated diffusion, osmosis, and active transport.

BIO.1D Students will describe the structure of the cell membrane and analyze how the structure is related to its primary function of regulating transport in and out of cells to maintain homeostasis.

BIO.1D.1 *Plan and conduct investigations to prove that the cell membrane is a semi-permeable, allowing it to maintain homeostasis with its environment through active and passive transport processes.*

BIO.1D.2 *Develop and use models to explain how the cell deals with imbalances of solute concentration across the cell membrane (i.e., hypertonic, hypotonic, and isotonic conditions, sodium/potassium pump).*

Conceptual Understanding: Cells grow and reproduce through a regulated cell cycle. Within multicellular organisms, cells repeatedly divide for repair, replacement, and growth. Likewise, an embryo begins as a single cell that reproduces to form a complex, multicellular organism through the processes of cell division and differentiation.

BIO.1E Students will develop and use models to explain the role of the cell cycle during growth, development, and maintenance in multicellular organisms.

BIO.1E.1 *Construct models to explain how the processes of cell division and cell differentiation produce and maintain complex multicellular organisms.*
BIO.1E.2 *Identify and describe the changes that occur in a cell during replication. Explore problems that might occur if the cell does not progress through the cycle correctly (cancer).*
BIO.1E.3 *Relate the processes of cellular reproduction to asexual reproduction in simple organisms (i.e., budding, vegetative propagation, regeneration, binary fission). Explain why the DNA of the daughter cells is the same as the parent cell.*
BIO.1E.4 ***Enrichment:*** *Use an engineering design process to investigate the role of stem cells in regeneration and asexual reproduction, then develop applications of stem cell research to solve human medical conditions.**

Biology

BIO.2 Energy Transfer

Conceptual Understanding: Organisms require energy to perform life functions. Cells are transformers of energy, continuously utilizing a complex sequence of reactions in which energy is transferred from one form to another, for example, from light energy to chemical energy to kinetic energy. Emphasis is on illustrating the inputs and outputs of matter and the transfer and transformation of energy in photosynthesis and cellular respiration. Assessment is limited to identification of the phases (i.e., glycolysis, citric acid cycle, and electron transport chain) in cellular respiration as well as light and light-independent reactions of photosynthesis and does not include specific biochemical reactions within the phases.

BIO.2 Students will explain that cells transform energy through the processes of photosynthesis and cellular respiration to drive cellular functions.

BIO.2.1 *Use models to demonstrate that ATP and ADP are cycled within a cell as a means to transfer energy.*
BIO.2.2 *Develop models of the major reactants and products of photosynthesis to demonstrate the transformation of light energy into stored chemical energy in cells. Emphasize the chemical processes in which bonds are broken and energy is released, and new bonds are formed and energy is stored.*
BIO.2.3 *Develop models of the major reactants and products of cellular respiration (aerobic and anaerobic) to demonstrate the transformation of the chemical energy stored in food to the available energy of ATP. Emphasize the chemical processes in which bonds are broken and energy is released, and new bonds are formed and energy is stored.*
BIO.2.4 *Conduct scientific investigations or computer simulations to compare aerobic and anaerobic cellular respiration in plants and animals, using real world examples.*
BIO.2.5 ***Enrichment:*** *Investigate variables (e.g., nutrient availability, temperature) that affect anaerobic respiration and current real-world applications of fermentation.*
BIO.2.6 ***Enrichment:*** *Use an engineering design process to manipulate factors involved in fermentation to optimize energy production.**

Biology

BIO.3 Reproduction and Heredity

Conceptual Understanding: Somatic cells contain homologous pairs of chromosomes, one member of each pair obtained from each parent, that form a diploid set of chromosomes in each cell. These chromosomes are similar in genetic information but may contain different alleles of these genes. For sexual reproduction, an offspring must inherit a haploid set from each parent. Haploid gametes are formed by meiosis, a specialized cell division in which the chromosome number is reduced by half. During meiosis, members of a homologous pair may exchange information and then are randomly sorted into gametes resulting in genetic variation in sex cells.

BIO.3A Students will develop and use models to explain the role of meiosis in the production of haploid gametes required for sexual reproduction.

BIO.3A.1 *Model sex cell formation (meiosis) and combination (fertilization) to demonstrate the maintenance of chromosome number through each generation in sexually reproducing populations. Explain why the DNA of the daughter cells is different from the DNA of the parent cell.*

BIO.3A.2 *Compare and contrast mitosis and meiosis in terms of reproduction.*

BIO.3A.3 *Investigate chromosomal abnormalities (e.g., Down syndrome, Turner's syndrome, and Klinefelter syndrome) that might arise from errors in meiosis (nondisjunction) and how these abnormalities are identified (karyotypes).*

Conceptual Understanding: Offspring inherit DNA from their parents. The genes contained in the DNA (genotype) determine the traits expressed in the offspring's phenotype. Alleles of a gene may demonstrate various patterns of inheritance. These patterns of inheritance may be followed through multiple generations within families.

BIO.3B Students will analyze and interpret data collected from probability calculations to explain the variation of expressed traits within a population.

BIO.3B.1 *Demonstrate Mendel's law of dominance and segregation using mathematics to predict phenotypic and genotypic ratios by constructing Punnett squares with both homozygous and heterozygous allele pairs.*

BIO.3B.2 *Illustrate Mendel's law of independent assortment using Punnett squares and/or the product rule of probability to analyze monohybrid crosses.*

BIO.3B.3 *Investigate traits that follow non-Mendelian inheritance patterns (e.g., incomplete dominance, codominance, multiple alleles in human blood types, and sex-linkage).*

BIO.3B.4 *Analyze and interpret data (e.g., pedigrees, family, and population studies) regarding Mendelian and complex genetic traits (e.g., sickle-cell anemia, cystic fibrosis, muscular dystrophy, color-blindness, and hemophilia) to determine patterns of inheritance and disease risk.*

Conceptual Understanding: Gene expression results in the production of proteins and thus determines the phenotypes of the organism. Changes in the DNA occur throughout an organism's life. Mutations are a source of genetic variation that may have a positive, negative, or no effect on the organism.

BIO.3C Students will construct an explanation based on evidence to describe how the structure and nucleotide base sequence of DNA determines the structure of proteins or RNA that carry out essential functions of life.

BIO.3C.1 *Develop and use models to explain the relationship between DNA, genes, and chromosomes in coding the instructions for the traits transferred from parent to offspring.*

BIO.3C.2 *Evaluate the mechanisms of transcription and translation in protein synthesis.*

BIO.3C.3 *Use models to predict how various changes in the nucleotide sequence (e.g., point mutations, deletions, and additions) will affect the resulting protein product and the subsequent inherited trait.*

BIO.3C.4 *Research and identify how DNA technology benefits society. Engage in scientific argument from evidence over the ethical issues surrounding the use of DNA technology (e.g., cloning, transgenic organisms, stem cell research, and the Human Genome Project, gel electrophoresis).*

BIO.3C.5 ***Enrichment:*** *Investigate current biotechnological applications in the study of the genome (e.g., transcriptome, proteome, individualized sequencing, and individualized gene therapy).*

Biology

BIO.4 Adaptations and Evolution

Conceptual Understanding: Evolution is a key unifying principle in biology. Differentiating between organic and chemical evolution and the analysis of the gradual changes in populations over time, helps students understand common features and differences between species and thus the relatedness between species. There are several factors that affect how natural selection acts on populations within their environments leading to speciation, extinction, and the current diversity of life on earth.

BIO.4 Students will analyze and interpret evidence to explain the unity and diversity of life.

BIO.4.1 *Use models to differentiate between organic and chemical evolution, illustrating the steps leading to aerobic heterotrophs and photosynthetic autotrophs.*

BIO.4.2 *Evaluate empirical evidence of common ancestry and biological evolution, including comparative anatomy (e.g., homologous structures and embryological similarities), fossil record, molecular/biochemical similarities (e.g., gene and protein homology), and biogeographic distribution.*

BIO.4.3 *Construct cladograms/phylogenetic trees to illustrate relatedness between species.*

BIO.4.4 *Design models and use simulations to investigate the interaction between changing environments and genetic variation in natural selection leading to adaptations in populations and differential success of populations.*

BIO.4.5 *Use Darwin's Theory to explain how genetic variation, competition, overproduction, and unequal reproductive success acts as driving forces of natural selection and evolution.*

BIO.4.6 *Construct explanations for the mechanisms of speciation (e.g., geographic and reproductive isolation).*

BIO.4.7 ***Enrichment:*** *Construct explanations for how various disease agents (bacteria, viruses, chemicals) can influence natural selection.*

Biology

BIO.5 Interdependence of Organisms and Their Environments

Conceptual Understanding: Complex interactions within an ecosystem affect the numbers and types of organisms that survive. Fluctuations in conditions can affect the ecosystem's function, resources, and habitat availability. Ecosystems are subject to carrying capacities and can only support a limited number of organisms and populations. Factors that can affect the carrying capacities of populations are both biotic and abiotic.

BIO.5 Students will Investigate and evaluate the interdependence of living organisms and their environment.

BIO.5.1 *Illustrate levels of ecological hierarchy, including organism, population, community, ecosystem, biome, and biosphere.*

BIO.5.2 *Analyze models of the cycling of matter (e.g., carbon, nitrogen, phosphorus, and water) between abiotic and biotic factors in an ecosystem and evaluate the ability of these cycles to maintain the health and sustainability of the ecosystem.*

BIO.5.3 *Analyze and interpret quantitative data to construct an explanation for the effects of greenhouse gases on the carbon dioxide cycle and global climate.*

BIO.5.4 *Develop and use models to describe the flow of energy and amount of biomass through food chains, food webs, and food pyramids.*

BIO.5.5 *Evaluate symbiotic relationships (e.g., mutualism, parasitism, and commensalism) and other co-evolutionary (e.g., predator-prey, cooperation, competition, and mimicry) relationships within specific environments.*

BIO.5.6 *Analyze and interpret population data, both density-dependent and density-independent, to define limiting factors. Use graphical representations (growth curves) to illustrate the carrying capacity within ecosystems.*

BIO.5.7 *Investigate and evaluate factors involved in primary and secondary ecological succession using local, real world examples.*

BIO.5.8 ***Enrichment:*** *Use an engineering design process to create a solution that addresses changing ecological conditions (e.g., climate change, invasive species, loss of biodiversity, human population growth, habitat destruction, biomagnification, or natural phenomena).**

BIO.5.9 ***Enrichment:*** *Use an engineering design process to investigate and model current technological uses of biomimicry to address solutions to real-world problems.**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

BOTANY

Botany, **a one-half credit course**, is a laboratory-based course applying basic biological principles to the study of plants. Topics include morphological characteristics of each division and variation in their reproduction, physiology, taxonomy, evolution, and the interactions of human society and plants. Laboratory activities, research, the use of technology, and the effective communication of results through various methods are integral components of this course. It is recommended that Botany is taken after the successful completion of Biology.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. The recommendation is that students should actively engage in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Botany

BOT.1 Plant Morphology, Cell Structure, and Function

Conceptual Understanding: Plants are a diverse and important part of the biosphere, providing oxygen, food, and shelter required for other organisms. The diversity of the plant kingdom is characterized by unique traits that are observed to identify the various plant divisions.

BOT.1 Students will investigate the morphology, anatomy, and physiology of plants.

BOT.1.1 *Analyze models (3-D, paper, and/or computer-based) to distinguish the basic morphology of the plant kingdom, with attention to structures and their related functions. Use cladograms or phylogenetic trees to identify evolutionary features that distinguish the plant kingdom from other kingdoms.*

BOT.1.2 *Using microscopes, observe, identify, record, and analyze (e.g., see and draw) cells and cell structures unique to plants. Use data measurements obtained from microscopy to compare the plant cells and organelle sizes between various examples (e.g., elodea, onion, or algae).*

BOT.1.3 *Describe the relationship between the structure and purpose of plant organs (e.g., roots, stems, and leaves).*

BOT.1.4 *Evaluate and explain how bacteria and fungi work symbiotically to enhance plant root function.*

BOT.1.5 *Calculate surface area of leaves/roots, and compare surface areas of various plant specimens to explain adaptations of the various plant types.*

BOT.1.6	*Demonstrate through model development and manipulation an understanding of plant biochemistry.*
BOT.1.7	*Conduct investigations, collect and analyze data, and communicate results that explain the processes of photosynthesis and cellular respiration (e.g., light intensity, light color, light distance, temperature, altering pH, oxygen availability, and carbon dioxide concentration).*
BOT.1.8	***Enrichment:*** *Use an engineering design process to manipulate a variable of choice to refine a protocol to optimize output of photosynthesis or cellular respiration.**
BOT.1.9	*Communicate the importance of carbon, hydrogen, oxygen, phosphorus, and nitrogen cycles to plant physiology through graphics such as poster or computer presentations.*
BOT.1.10	*Identify and compare various live plant examples to explore plant morphological diversity, including leaf number, structure, and arrangement; root modifications; and flower structure and arrangement. Produce a visual product (e.g., an electronic presentation) to identify and communicate patterns of similarity and differences between the lab specimens.*
BOT.1.11	*Compare and contrast functions of the various characteristics found in plant divisions and utilize dichotomous keys to identify plant species.*

Botany

BOT.2 Plant Evolution

Conceptual Understanding: Plants have been naturally selected to survive in a variety of habitats, from aquatic to arboreal. The development of these characteristics is used to construct cladograms that illustrate the evolution of plants.

BOT.2 Students will identify evolutionary modifications necessary for the terrestrial survival of plants.

BOT.2.1	*Summarize and justify the characteristics of nonvascular algae (blue-green and green algae) and bryophytes that provide evidence of evolution within the plant kingdom.*
BOT.2.2	*Referencing the USDA plants database, identify, compare, and contrast seedless, naked seed, and enclosed-seed modifications for reproduction. Calculate the occurrence of seed types in given habitats.*
BOT.2.3	*Summarize and justify the characteristics of angiosperms and gymnosperms that lead to their success as terrestrial plants.*
BOT.2.4	*Research information to develop, produce, and communicate a scientifically justifiable argument for the rapid amplification and success of angiosperm compared to other plant divisions.*
BOT.2.5	***Enrichment:*** *Referencing the National Center for Biotechnology Information's gene/protein databases, propose and design a scientifically supportable cladogram or phylogenetic tree that illustrates the evolutionary modifications of the plant kingdom using genetic (DNA) or protein sequence comparisons/alignments.*

Botany

BOT.3 Plant Reproduction

Conceptual Understanding: Reproduction in plants occurs through different methods. Understanding the reproductive methods of plants allows humans to use these methods in agriculture and food development.

BOT.3 Students will characterize the reproductive strategies of plants.

BOT.3.1 *Describe the various processes of asexual reproduction and vegetative propagation used by plants. Communicate the importance of these reproductive methods in regard to human food production.*

BOT.3.2 ***Enrichment:*** *Research and present an agronomically important crop (e.g., potato, sweet potato, pineapple, or strawberry) that is produced via vegetative propagation (non-GMOs) for human consumption. Include evidence-based arguments that identify the potential benefits and negative effects of this method of crop production.*

BOT.3.3 *Compare and contrast the consequences of the following reproductive methods: asexual reproduction, vegetative propagation, and sexual reproduction.*

BOT.3.4 *Plan and conduct comparative flower dissection to identify reproductive structures within the flower.*

BOT.3.5 *Compare the similarities between corresponding plant reproductive structures from a variety of species. Record via drawings of observed dissection specimens, and explain the similarities and differences observed.*

BOT.3.6 *Identify differences in flower structure and shape. Provide a rationale that explains the value of these differences in flower structure to reproductive success (e.g., pollinators, flower shape, smell, color, size, orientation).*

BOT.3.7 *Plan, conduct, and communicate the results of a comparative laboratory investigation of differing fruit types.*

BOT.3.8 *Using laboratory data, correctly categorize fruits, vegetables, nuts, modified stems, or other plant parts. Compare the scientific definitions of these terms to those used by the general public/society and the USDA to categorize food.*

Botany

BOT.4 Society's Reliance on Plants

Conceptual Understanding: Human reliance on plants and plant products began with food and building materials. This use has expanded to include medicine, industrial clean up (phytoremediation) of human-generated byproducts and toxic waste, and plant examples used in biomimicry for solving human problems.

BOT.4 Students will explore the global value of plants and the interaction between humans and plants.

BOT.4.1 *Identify plants used in the bioremediation of an area due to natural processes (e.g., fire), industrial pollution, or wars, and develop and communicate a plan to remediate a habitat impacted by human interactions (e.g., carbon sinks, phytoremediation, or heavy metal detoxification).*

BOT.4.2 ***Enrichment:*** *Use an engineering design process to define a problem, design, construct, evaluate, and improve a habitat impacted by human interactions.**

BOT.4.3 *Investigate historical and modern medicinal uses of plants.*

BOT.4.4 *Investigate the industrial use of plants.*

BOT.4.5 *Explore the impacts (both positive and negative) of plant biotechnology/GMOs on human society. Present findings using digital media or technology, and include evidence using graphs or charts.*

BOT.4.6 ***Enrichment:*** *Use an engineering design process to design and conduct an investigation that uses biomimicry to provide a plant-based solution to an environmental challenge.**

Botany

BOT.5 Plant Adaptations to Varying Habitats

Conceptual Understanding: Before animal life forms can survive within a habitat, there must be an existing plant population. Plants have specific adaptations that allow them to survive in habitats.

BOT.5 Students will explore adaptations that allow plants to survive in various habitats.

BOT.5.1 *Research plants found in various habitats. Analyze how plants use adaptations for survival in these habitats including extreme habitats.*
BOT.5.2 *Relate atmospheric factors to biodiversity (e.g., climate as determined by temperature and precipitation).*
BOT.5.3 *Construct a model using technology that illustrates the levels of succession within a habitat (e.g., graveyard exploration, forest fire area, or reclamation sites).*
BOT.5.4 ***Enrichment:*** *Use an engineering design process to design and build a plant model based on extreme environment criteria to overcome the difficulties presented by this environment. Identify revisions to the proposed model over time.**

Botany

BOT.6 Local Plant Investigations

Conceptual Understanding: The plant diversity within the local environment impacts the health of the ecosystem. The ability to identify the plants within an ecosystem is a skill that will benefit students throughout life.

BOT.6 Students will ask questions, plan, and conduct field investigations on local plant communities.

BOT.6.1 *Conduct transects/plot studies to determine species, biodiversity, or health of a plant community. (Plots may be linear or a quadrat (square or circular) depending on the habitat. (Typically, relative density, relative dominance, and relative frequency of each species are calculated to infer an importance value of the species in the plot.)*
BOT.6.2 *Compare and contrast genomes using plant genetic databases (e.g., BLAST or plant GDB).*
BOT.6.3 ***Enrichment:*** *Use an engineering design process to define a problem, design, construct, evaluate, and improve a societal concern with the aid of plants (e.g., irrigation, water conservation, urban shading, green-space development, food deserts, or other local needs or issues).**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

CHEMISTRY

Chemistry, **a one-credit course,** is an elective and should be a rigorous course to prepare students for careers in science, technology, engineering, integrated STEM activities, and mathematics. Chemistry explores empirical concepts central to all areas of science. These concepts should be explored in-depth using both quantitative and qualitative analysis, computational and experimental rigor, and the use of inquiry-based methods of teaching. To accomplish a level of sophistication and depth, chemistry teachers should extend concepts mastered by students in earlier grades. Cornerstone objectives of chemistry that must be addressed and readdressed throughout the course are dimensional analysis, naming compounds, balancing equations, and stoichiometry. To be successful in Chemistry, it is recommended that students have completed Algebra I (Integrated Math I), and be enrolled in an upper level math course.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should actively engage in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Chemistry

CHE.1 Mathematical and Computational Analysis

Conceptual Understanding: Mathematical and computational analysis is a key component of scientific investigation and prediction of outcomes. These components create a more student-centered classroom.

CHE.1 Students will use mathematical and computational analysis to evaluate problems.

CHE.1.1 *Use dimensional analysis (factor/label) and significant figures to convert units and solve problems.*

CHE.1.2 *Design and conduct experiments using appropriate measurements, significant figures, graphical analysis to analyze data.*

CHE.1.3 ***Enrichment:*** *Research information from multiple appropriate sources and assess the credibility, accuracy, possible bias, and conclusions of each publication.*

Chemistry

CHE.2 Atomic Theory

Conceptual Understanding: Atomic theory is the foundation of modern chemistry concepts. Students must be presented with a solid foundation of the atom and its components. These concepts lead to an understanding of the interactions of these components to explain macro-observations of the world.

CHE.2 Students will demonstrate an understanding of the atomic structure and the historical developments leading to modern atomic theory.

CHE.2.1 *Investigate the historical progression leading to the modern atomic theory, including, but not limited to, work done by Dalton, Rutherford's gold foil experiment, Thomson's cathode ray experiment, Millikan's oil drop experiment, and Bohr's interpretation of bright line spectra.*

CHE.2.2 *Construct models (e.g., ball and stick, online simulations, mathematical computations) of atomic nuclei to explain the abundance weighted average (relative mass) of elements and isotopes on the published mass of elements.*

CHE.2.3 *Investigate absorption and emission spectra to interpret explanations of electrons at discrete energy levels using tools such as online simulations, spectrometers, prisms, flame tests, and discharge tubes. Explore both laboratory experiments and real-world examples.*

CHE.2.4 *Research appropriate sources to evaluate the way absorption and emission spectra are used to study astronomy and the formation of the universe.*

Chemistry

CHE.3 Periodic Table

Conceptual Understanding: Modern chemistry is based on the predictability of atomic behavior. Periodic patterns in elements led to the development of the periodic table. Electron configuration is a direct result of this periodic behavior. The predictable behavior of electrons has led to the discovery of new compounds, elements, and atomic interactions. Predictability of atom behavior is a key to understanding ionic and covalent bonding and production of compounds or molecules.

CHE.3 Students will demonstrate an understanding of the periodic table as a systematic representation to predict properties of elements.

CHE.3.1 *Explore and communicate the organization of the periodic table, including history, groups, families, family names, metals, nonmetals, metalloids, and transition metals.*

CHE.3.2 *Analyze properties of atoms and ions (e.g., metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity and electron affinity, ionization energy, and atomic/ionic radii) using periodic trends of elements based on the periodic table.*

CHE.3.3 *Analyze the periodic table to identify quantum numbers (e.g., valence shell electrons, energy level, orbitals, sublevels, and oxidation numbers).*

Chemistry

CHE.4 Bonding

Conceptual Understanding: A firm understanding of bonding is necessary to further development of the basic chemical concepts of compounds and chemical interactions.

CHE.4 Students will demonstrate an understanding of the types of bonds and resulting atomic structures for the classification of chemical compounds.

CHE.4.1 *Develop and use models (e.g., Lewis dot, 3-D ball-stick, 3-D printing, or simulation programs such as PhET) to predict the type of bonding between atoms and the shape of simple compounds.*

CHE.4.2 *Use models such as Lewis structures and ball and stick models to depict the valence electrons and their role in the formation of ionic and covalent bonds.*

CHE.4.3 *Predict the ionic or covalent nature of different atoms based on electronegativity trends and/or position on the periodic table.*

CHE.4.4 *Use models and oxidation numbers to predict the type of bond, shape of the compound, and the polarity of the compound.*

CHE.4.5 *Use models of simple hydrocarbons to exemplify structural isomerism.*

CHE.4.6 *Use mathematical and computational analysis to determine the empirical formula and the percent composition of compounds.*

CHE.4.7 *Use scientific investigation to determine the percentage of composition for a substance (e.g., sugar in gum, water and/or unpopped kernels in popcorn, percent water in a hydrate). Compare results to justify conclusions based on experimental evidence.*

CHE.4.8 *Plan and conduct controlled scientific investigations to produce mathematical evidence of the empirical composition of a compound.*

Chemistry

CHE.5 Naming Compounds

Conceptual Understanding: Polyatomic ions (radicals) and oxidation numbers are used to predict how metallic ions, nonmetals, and transition metals are used in naming compounds.

CHE.5 Students will investigate and understand the accepted nomenclature used to identify the name and chemical formulas of compounds.

CHE.5.1 *Use the periodic table and a list of common polyatomic ions as a model to derive chemical compound formulas from compound names and compound names from chemical formulas.*

CHE.5.2 *Generate formulas of ionic and covalent compounds from compound names. Discuss compounds in everyday life and compile lists and uses of these chemicals.*

CHE.5.3 *Generate names of ionic and covalent compounds from their formulas. Name binary compounds, binary acids, stock compounds, ternary compounds, and ternary acids.*

Chemistry

CHE.6 Chemical Reactions

Conceptual Understanding: Understanding chemical reactions and predicting products of these reactions is essential to student success.

CHE.6 Students will demonstrate an understanding of the types, causes, and effects of chemical reactions.

CHE.6.1 *Develop and use models to predict the products of chemical reactions (e.g., synthesis reactions; single replacement; double displacement; and decomposition, including exceptions such as decomposition of hydroxides, chlorates, carbonates, and acids). Discuss and/or compile lists of reactions used in everyday life.*

CHE.6.2 *Plan, conduct, and communicate the results of investigations to demonstrate different types of simple chemical reactions.*

CHE.6.3 *Use mathematics and computational analysis to represent the ratio of reactants and products in terms of masses, molecules, and moles (stoichiometry).*

CHE.6.4 *Use mathematics and computational analysis to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. Give real-world examples (e.g., burning wood).*

CHE.6.5 *Plan and conduct a controlled scientific investigation to produce mathematical evidence that mass is conserved. Use percent error to analyze the accuracy of results.*

CHE.6.6 *Use mathematics and computational analysis to support the concept of percent yield and limiting reagent.*

CHE.6.7 *Plan and conduct a controlled scientific investigation to produce mathematical evidence to predict and confirm the limiting reagent and percent yield in the reaction. Analyze quantitative data, draw conclusions, and communicate findings. Compare and analyze class data for validity.*

Chemistry

CHE.7 Gas Laws

Conceptual Understanding: The comparison and development of the molecular states of matter are an integral part of understanding matter. Pressure, volume, and temperature are imperative to understanding the states of matter.

CHE.7 Students will demonstrate an understanding of the structure and behavior of gases.

CHE.7.1 *Analyze the behavior of ideal and real gases in terms of pressure, volume, temperature, and number of particles.*

CHE.7.2 ***Enrichment:*** *Use an engineering design process to develop models (e.g., online simulations or student interactive activities) to explain and predict the behavior of each state of matter using the movement of particles and intermolecular forces to explain the behavior of matter.**

CHE.7.3 *Analyze and interpret heating curve graphs to explain the energy relationship between states of matter (e.g., thermochemistry-water heating from -20^{o}C to 120^{o}C).*

CHE.7.4 *Use mathematical computations to describe the relationships comparing pressure, temperature, volume, and number of particles, including Boyle's law, Charles's law, Dalton's law, combined gas laws, and ideal gas laws.*

CHE.7.5 ***Enrichment:*** *Use an engineering design process and online simulations or lab investigations to design and model the results of controlled scientific investigations to produce mathematical evidence that confirms the gas-laws relationships.**

CHE.7.6 *Use the ideal gas law to support the prediction of volume, mass, and number of particles produced in chemical reactions (i.e., gas stoichiometry).*

CHE.7.7 *Plan and conduct controlled scientific investigations to produce mathematical evidence that confirms that reactions involving gases conform to the law of conservation of mass.*

CHE.7.8 ***Enrichment:*** *Using gas stoichiometry, calculate the volume of carbon dioxide needed to inflate a balloon to occupy a specific volume. Use an engineering design process to design, construct, evaluate, and improve a simulated air bag.**

Chemistry

CHE.8 Solutions

Conceptual Understanding: Solutions exist as solids, liquids, or gases. Solution concentration is expressed by specifying relative amounts of solute to solvent.

CHE.8 **Students will demonstrate an understanding of the nature of properties of various types of chemical solutions.**

CHE.8.1 *Use mathematical and computational analysis to quantitatively express the concentration of solutions using the concepts such as molarity, percent by mass, and dilution.*

CHE.8.2 *Develop and use models (e.g., online simulations, games, or video representations) to explain the dissolving process in solvents on the molecular level.*

CHE.8.3 *Analyze and interpret data to predict the effect of temperature and pressure on solids and gases dissolved in water.*

CHE.8.4 *Design, conduct, and communicate the results of experiments to test the conductivity of common ionic and covalent compounds in solution.*

CHE.8.5 *Use mathematical and computational analysis to analyze molarity, molality, dilution, and percentage dilution problems.*

CHE.8.6 *Design, conduct, and communicate the results of experiments to produce a specified volume of a solution of a specific molarity, and dilute a solution of a known molarity.*

CHE.8.7 *Use mathematical and computational analysis to predict the results of reactions using the concentration of solutions (i.e., solution stoichiometry).*

CHE.8.8 ***Enrichment:*** *Investigate parts per million and/or parts per billion as it applies to environmental concerns in your geographic region, and reference laws that govern these factors.*

Chemistry (Enrichment)

CHE.9 Acids and Bases (Enrichment)

CHE.9 **Enrichment: Students will understand the nature and properties of acids, bases, and salt solutions.**

CHE.9.1 ***Enrichment:*** *Analyze and interpret data to describe the properties of acids, bases, and salts.*

CHE.9.2 ***Enrichment:*** *Analyze and interpret data to identify differences between strong and weak acids and bases (i.e., dissociation).*

CHE.9.3 ***Enrichment:*** *Plan and conduct investigations using the pH scale to classify acid and base solutions.*

CHE.9.4 ***Enrichment:*** *Analyze and evaluate the Arrhenius, Bronsted-Lowry, and Lewis acid-base definitions.*

CHE.9.5 ***Enrichment:*** *Use mathematical and computational thinking to calculate pH from the hydrogen-ion concentration.*

CHE.9.6 ***Enrichment:*** *Obtain, evaluate, and communicate information about how buffers stabilize pH in acid-base reactions.*

Chemistry (Enrichment)

CHE.10 Thermochemistry (Enrichment)

CHE.10 **Enrichment: Students will understand that energy is exchanged or transformed in all chemical reactions.**

CHE.10.1 ***Enrichment:*** *Construct explanations to explain how temperature and heat flow in terms of the motion of molecules (or atoms).*

CHE.10.2 ***Enrichment:*** *Classify chemical reactions and phase changes as exothermic or endothermic based on enthalpy values. Use a graphical representation to illustrate the energy changes involved.*

CHE.10.3 ***Enrichment:*** *Analyze and interpret data from energy diagrams and investigations to support claims that the amount of energy released or absorbed during a chemical reaction depends on changes in total bond energy.*

CHE.10.4 ***Enrichment:*** *Use mathematical and computational thinking to solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.*

Chemistry (Enrichment)

CHE.11 Equilibrium (Enrichment)

CHE.11 **Enrichment: Students will understand that chemical equilibrium is a dynamic process at the molecular level.**

CHE.11.1 ***Enrichment:*** *Construct explanations to explain how to use Le Chatelier's principle to predict the effect of changes in concentration, temperature, and pressure.*

CHE.11.2 ***Enrichment:*** *Predict when equilibrium is established in a chemical reaction.*

CHE.11.3 ***Enrichment:*** *Use mathematical and computational thinking to calculate an equilibrium constant expression for a reaction.*

Chemistry (Enrichment)

CHE.12 Organic Nomenclature (Enrichment)

CHE.12 **Enrichment: Students will understand that the bonding characteristics of carbon allow the formation of many different organic molecules with various sizes, shapes, and chemical properties.**

CHE.12.1 ***Enrichment:*** *Construct explanations to explain the bonding characteristics of carbon that result in the formation of basic organic molecules.*

CHE.12.2 ***Enrichment:*** *Obtain information to communicate the system used for naming the basic linear hydrocarbons and isomers that contain single bonds, simple hydrocarbons with double and triple bonds, and simple molecules that contain a benzene ring.*

CHE.12.3 ***Enrichment:*** *Develop and use models to identify the functional groups that form the basis of alcohols, ketones, ethers, amines, esters, aldehydes, and organic acids.*

Overarching (start to finish) SEPs for Inquiry Extension of Labs

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Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

EARTH AND SPACE SCIENCE

The Earth and space science course, **a one-credit course,** provides opportunities for students to continue to develop and communicate a basic understanding of the Earth and its place in the universe through lab-based activities, integrated STEM activities, inquiry, mathematical expressions, and concept exploration. The Earth and space science course will help students apply scientific concepts in natural settings and guide them to become responsible stewards of Earth's natural resources.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a lab-based course, students are expected to design and conduct investigations using appropriate equipment, measurement, and safety procedures. The recommendation is that students should be actively engaged in inquiry activities, lab experiences, and scientific research for a minimum of 30% of the class time.

Although the standards and performance objectives do not have to be taught in the order presented in this document, they are arranged from the universe, through the solar system, the interacting systems of planet Earth, and the interrelationships between our planet and humans throughout time. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Earth and Space Science

ESS.1 Earth in the Universe

Conceptual Understanding: The planet Earth is a very small part of a very large universe that has developed over a huge expanse of time.

ESS.1.A Students will develop an understanding of the universe, its development, immense size, and composition.

ESS.1A.1 *Describe the Big Bang theory and summarize observations (e.g., cosmic microwave background radiation, Hubble's law, and redshift caused by the Doppler effect) as evidence to support the formation and expansion of the universe.*

ESS.1A.2 *Interpret information from the Hertzsprung -Russell diagram to differentiate types of stars, including our sun, according to size, magnitude, and classification.*

ESS.1A.3 *Organize and interpret data sets for patterns and trends to compare and contrast stellar evolution in order to explain and communicate how a star changes during its life.*

ESS.1A.4 *Research and explain how nuclear fusion in stars and supernova lead to the formation of all other elements.*

Conceptual Understanding: The sun, moon, and planets have predictable patterns that are explained by forces and laws. Patterns of motion in the solar system can be described and predicted based on observations and an understanding of gravity.

ESS.1.B Students will develop an understanding of Earth, the solar system, and the laws that predict the motion of celestial bodies.

ESS.1B.1 *Read and evaluate scientific information for mechanisms/results (e.g., the solar nebular theory) to explain how the solar system was formed. Cite evidence and develop a logical argument.*

ESS.1B.2 *Compare and contrast celestial bodies (e.g., planets, natural satellites, comets, asteroids, and the Oort cloud) and their motion in our solar system (e.g., revolution and rotation). Build an Analemma calendar.*

ESS.1B.3 *Design a model (e.g., a gravity simulation using PVC and a neoprene screen) to demonstrate Kepler's laws and the relationships of the orbits of objects in our solar system. Relate them to Newton's law of universal gravitation and laws of motion.*

Earth and Space Science

ESS.2 Earth Structure and History

Conceptual Understanding: Earth's interior is divided into a solid inner core, a liquid outer core, a pliable mantle, and a solid crust. Even though the crust is solid, it is always in motion and is recycled through time.

ESS.2.A Students will develop an understanding of the structure and composition of Earth and its materials.

ESS.2A.1 *Analyze and interpret data to explain and communicate the differentiation of Earth's internal chemical structure (e.g., core, mantle, and crust) using the production of internal heat from the radioactive decay of unstable isotopes and gravitational energy.*

ESS.2A.2 *Analyze and interpret data to explain and communicate the differentiation of Earth's physical divisions (e.g., lithosphere and asthenosphere) using data from seismic waves and Earth's magnetic field.*

ESS.2A.3 *Investigate the physical and/or chemical characteristics of mineral specimens to identify minerals and mineral deposits/groups (e.g., oxides, carbonates, halides, sulfides, sulfates, silicates, and phosphates). Include the relationship between chemical bonds, chemical formulas, mineral use, and mineral properties.*

ESS.2A.4 *Investigate the physical and/or chemical characteristics of rock specimens to identify and categorize igneous, sedimentary, and metamorphic rocks. Include the processes that generate the transformation of rocks.*

Conceptual Understanding: Radioactive decay lifetimes and isotopic content in rocks provide a way of dating rock formations and thereby fixing the scale of geological time. Plate tectonics is the unifying theory that explains the movements of rocks on Earth's surface and provides a comprehensive account of its geological history. Physical and chemical weathering is a result of the interactions of Earth's geosphere, hydrosphere, atmosphere, and biosphere.

ESS.2.B Students will develop an understanding of the history and evolution of the earth.

ESS.2B.1 *Research, analyze, and evaluate the contributions of William Smith, James Hutton, Nicolaus Steno, Charles Lyell, and others to physical geology.*

ESS.2B.2 *Apply different techniques (e.g., superposition, original horizontality, cross-cutting relationships, lateral continuity, principle of inclusions, fossil succession, and unconformities) to analyze and interpret the relative age of actual sequences, models, or photographs.*

ESS.2B.3 *Use mathematical concepts to calculate the absolute age of earth materials using actual or simulated isotope ratios.*

ESS.2B.4 *Research, analyze, and explain the origin of geologic features and processes that result from plate tectonics, including sea floor spreading, earthquake activity, volcanic activity, mountain building, and location of natural resources.*

ESS.2B.5 *Use mathematical representations to interpret seismic graphs to triangulate the location of an earthquake's epicenter and magnitude and to correlate the frequency and magnitude of an earthquake.*

ESS.2B.6 *Plan and conduct a scientific investigation to determine how factors (e.g., wind velocity, water velocity, ice, and temperature) may affect the rate of weathering.*

ESS.2B.7 ***Enrichment:*** *Use an engineering design process to design a model to simulate the formation of caves and karst topography by groundwater.**

Earth and Space Science

ESS.3 Earth's Systems and Cycles

Conceptual Understanding: Earth's surface is comprised of the geosphere, hydrosphere, atmosphere, and biosphere, all of which are interconnected. The complex and dynamic interactions between these systems have shaped Earth, influenced climate, and shaped the evolution of life.

ESS.3 Students will develop an understanding of Earth's systems and cycles.

ESS.3.1 *Use mathematical representations (e.g., latitude, longitude, and maps) to calculate the angle of noon solar incidence and relate the value to day length, distribution of sunlight, and seasonal change.*

ESS.3.2 ***Enrichment:*** *Use an engineering design process to explore the concepts of passive solar architecture to design a structure that best utilizes solar incidence.**

ESS.3.3 *Explain how temperature and density of ocean water influence circulation.*

ESS.3.4 *Research and communicate information to explain the importance of the transfer of thermal energy among the hydrosphere, geosphere, and atmosphere. Include the unique physical and chemical properties of water, the water cycle, and energy transfer within the rock cycle.*

ESS.3.5 *Analyze and interpret weather data using maps and global weather systems to explain and communicate the relationships among air masses, pressure systems, and frontal boundaries.*

ESS.3.6 *Construct an explanation from data sets to obtain and evaluate scientific information to construct scientific arguments on changes in climate caused by various natural factors (e.g., plate tectonics and continent location and Milankovitch cycles) versus anthropogenic factors (e.g., fossil fuel use and agricultural factors).*

ESS.3.7 *Cite evidence and develop logical arguments to identify the cause and effect relationships of the evolutionary milestones (e.g., photosynthesis and the atmosphere, the evolution of multicellular animals, the development of shells, and the colonization of terrestrial environments by plants and animals) that most profoundly shaped Earth's systems.*

ESS.3.8 *Analyze and interpret the record of shared ancestry, evolution, and extinction as related to natural selection using fossils.*

Earth and Space Science

ESS.4 Earth's Resources and Human Activity

Conceptual Understanding: The dynamic Earth impacts human society. Natural hazards and other geologic events have shaped the course of human history. In addition, humans also impact the Earth through resource extraction and land use.

ESS.4 Students will develop an understanding of Earth's resources and the impact of human activities.

ESS.4.1 *Research, evaluate, and communicate about how human life on Earth shapes Earth's systems and responds to the interaction of Earth's systems (e.g., geosphere, hydrosphere, atmosphere, and biosphere). Examine how geochemical and ecological processes interact through time to cycle matter and energy and how human activity alters the rates of these processes.*

ESS.4.2 *Research, assess, and communicate how Earth's systems influence the distribution of life, including how various natural hazards and geologic events (e.g., volcanic eruptions, earthquakes, landslides, tornadoes, and hurricanes) have shaped the course of human history.*

ESS.4.3 *Analyze earthquake and volcanic data to determine patterns that can lead to predicting such hazards and mitigating impact to humans.*

ESS.4.4 ***Enrichment:*** *Use an engineering design process to research, develop, and test models to aid in the responsible management of natural resources (e.g., recycling, composting, and energy usage).**

ESS.4.5 ***Enrichment:*** *Research and communicate regarding geoscience career options (e.g., geologist, petroleum engineer, meteorologist, paleontologist, astronomer, and oceanographer.*

Overarching (start to finish) SEPs for Inquiry Extension of Labs

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- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

ENVIRONMENTAL SCIENCE

Environmental science, **a one-half credit course**, is a laboratory- or field-based course that explores ways in which the environment shapes living communities. Human sustainability and environmental balance are emphasized. Laboratory activities, research, the use of technology, and the effective communication of results through various methods are integral components of this course, which also emphasizes a student-centered and collaborative classroom environment.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world that increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. The recommendation is that students should be actively engaged in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Environmental Science

ENV.1 Biosphere and Biodiversity

Conceptual Understanding: The biosphere is a system of biomes, each with unique characteristics. These characteristics are classified as biotic or abiotic. The environment in which humans live is dependent on a system of cycles. These biogeochemical cycles are the water, nitrogen, carbon, and phosphorus cycles. The flow of energy within the environment is critical for the success of life. The biodiversity within a biome is fragile and easily affected by human actions. Plant and animal populations are dynamic and are demonstrated through graphical analysis.

ENV.1 Students will investigate the interdependence of diverse living organisms and their interactions with the components of the biosphere.

ENV.1.1 *Identify, investigate, and evaluate the interactions of the abiotic and biotic factors that determine the types of organisms that live in major biomes.*

ENV.1.2 *Evaluate evidence in nonfiction text to explain how biological or physical changes within biomes affect populations and communities and how changing conditions may result in altered ecosystems.*

ENV.1.3 *Use models to explain why the flow of energy through an ecosystem can be illustrated by a pyramid with less energy available at the higher trophic levels compared to lower levels.*

ENV.1.4 *Describe symbiotic relationships (e.g., mutualism, parasitism, and commensalism) and other co-evolutionary (e.g., predator-prey, cooperation, competition, and mimicry) relationships within specific environments.*

ENV.1.5 *Develop and use models to diagram the flow of nitrogen, carbon, and phosphorus through the environment.*

ENV.1.6 *Use mathematics, graphics, and informational text to determine how population density-dependent and density-independent limiting factors affect populations and diversity within ecosystems. Use technology to illustrate and compare a variety of population-growth curves.*

ENV.1.7 *Analyze and interpret quantitative data to construct explanations of how the carrying capacity of an ecosystem may change as the availability of resources changes.*

ENV.1.8 *Utilize data to communicate changes within a given population and the environmental factors that may have impacted these changes (e.g., weather patterns, natural disasters)*

ENV.1.9 *Evaluate and communicate data that explains how human activity may impact biodiversity (e.g., introduction, removal, and reintroduction of an organism within an ecosystem; land usage) and genetic variations of organisms, including endangered and threatened species.*

ENV.1.10 ***Enrichment:*** *Engage in scientific argument from evidence the benefits versus harm of genetically modified organisms.*

Environmental Science

ENV.2 Natural Resources Use and Conservation

Conceptual Understanding: The environment is affected by human demand for its resources. However, through conservation applications, a balance may be reached between human sustainability and the environment.

ENV.2 Students will relate the impact of human activities on the environment, conservation activities, and efforts to maintain and restore ecosystems.

ENV.2.1 *Differentiate between renewable and nonrenewable resources, and compare and contrast the pros and cons of using these resources.*

ENV.2.2 *Investigate and research the pros and cons of using traditional sources of energy (e.g., fossil fuels) and alternative sources of energy (e.g., water, wind, geothermal, biomass/biofuels, solar).*

ENV.2.3 *Compare and contrast biodegradable and nonbiodegradable wastes and their significance in landfills.*

ENV.2.4 *Examine solutions for developing, conserving, managing, recycling, and reusing energy and mineral resources to minimize impacts in natural systems (e.g., agricultural soil use, mining for coal, construction sites, and exploration of petroleum and natural gas sources).*

ENV.2.5 *Research various resources related to water quality and pollution (e.g., nonfictional text, EPA's Surf Your Watershed, MDEQ publications) and communicate the possible effects on the environment and human health.*

ENV.2.6 ***Enrichment:*** *Obtain water from a local source (e.g., stream on campus, rainwater, ditch water) to monitor water quality over time, using a spreadsheet program to graphically represent collected data.*

Environmental Science

ENV.3 Human Activities and Climate Change

Conceptual Understanding: Humans are a part of their environment and may have a detrimental impact on the environment. Using evidence based on scientific research, efforts are underway to repair the environment. Historical and current regional and global models illustrate the changes in the environment.

ENV.3 Students will discuss the direct and indirect impacts of certain types of human activities on the Earth's climate.

ENV.3.1 *Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations have resulted in atmospheric and climate changes.*

ENV.3.2 *Interpret data and climate models to predict how global and regional climate change can affect Earth's systems (e.g., precipitation, temperature, impacts on sea level, global ice volumes, and atmosphere and ocean composition).*

ENV.3.3 *Use satellite imagery and other resources to analyze changes in biomes over time (e.g., glacial retreat, deforestation, desertification) and propose strategies to reduce the impact of human activities leading to these issues.*

ENV.3.4 ***Enrichment:*** *Determine mathematically an individual's impact on the environment (carbon footprint, water usage, landfill contribution) and develop a plan to reduce personal contribution.*

Environmental Science

ENV.4 Human Sustainability

Conceptual Understanding: Human health is dependent on the environment. Changes within an environment, whether natural or man-made, may lead to the spread of disease. Sudden environmental changes (e.g., tsunami or volcanic activity) lead to human migration into other areas of the environment. Case studies illustrate the need to intervene in environmental change, when possible, to improve health issues (e.g., smog's effect on asthma patients).

ENV.4 Students will demonstrate an understanding of the interdependence of human sustainability and the environment.

ENV.4.1 *Identify human impact and develop a solution for protection of the atmosphere, considering pollutants (e.g., acid rain, air pollution, smog, ozone layer, or increased levels of greenhouse gases) and the impacts of pollutants on human health (e.g., asthma, COPD, emphysema, and cancer).*

ENV.4.2 *Evaluate data and other information to explain how key natural resources (e.g., water sources, fertile soils, concentrations of minerals, and fossil fuels), natural hazards, and climate changes influence human activity (e.g., mass migrations, human health).*

ENV.4.3 ***Enrichment:*** *Research and analyze case studies to determine the impact of human-related and natural environmental changes on human health and communicate possible solutions to reduce/resolve the dilemma.*

ENV.4.4 ***Enrichment:*** *Explore online resources related to air pollution to determine air quality in a geographic area and communicate the possible effects on the environment and human health.*

ENV.4.5 ***Enrichment:*** *Use an engineering design process to define a problem, design, construct, evaluate, and improve a device or method to reduce or prevent human impact on a natural resource (e.g., build a water filter, design an air purifier, develop a method to prevent parking lot pollution from entering a watershed).**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

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FOUNDATIONS OF BIOLOGY

Foundations of Biology, **a one-credit course**, is a research and inquiry-based course designed to give students the basic knowledge needed prior to attempting the rigorous Biology course required for graduation. This course is NOT a required prerequisite for Biology. However, if selected as a science elective, Foundations of Biology should not be taken after the successful completion of Biology. Concepts covered in this course include the history of biology and its impacts on society, the chemistry of life, organization and energy in living systems, the molecular basis of heredity, biological evolution, and ecological principals.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and appropriate safety measures and practices. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Foundations of Biology

FB.1 History of Biology and Impacts on Society

Conceptual Understanding: The history of science is a compilation of the works of many people. To understand science and its applications, the history of scientific experiments and developments must be understood. The needs of society have been the driving force behind numerous advances in science and technology. Advances in science and technology have forever changed, and will continue to change, society.

FB.1 Students will relate the importance of significant historical biological experiments and their impact of these on research, development, and society.

FB.1.1 *Identify and communicate the contributions of famous scientists and their experiments that formed fundamental scientific principles (e.g., Robert Hooke, Schleiden/ Schwann/Virchow, Griffith, Avery/MacLeod/McCarty, Hershey/Chase, Rosalind Franklin, Gregor Mendel, Watson/Crick, Pasteur, and Charles Darwin).*

FB.1.2 *Trace and model the historical development of scientific ideas and theories (e.g., creation of the microscope, discovery of cells/cell theory, discovery of DNA/RNA, double helical shape of DNA, evolution/natural selection, endosymbiosis) through the development of a timeline.*

FB.1.3 *Research, analyze, explain, and communicate how scientific enterprise relates to society and classic inventions (e.g., microscope, blood typing, gel electrophoresis equipment, DNA sequencing technology).*

FB.1.4 ***Enrichment**: Research, analyze, explain, and communicate the influence of society, including cultural components, on the direction and progress of science and technology (e.g., medical treatments, emerging viruses, antibiotic resistance, vaccinations and re-emergent diseases, alternative energy development, and/or biomimicry.*

Foundations of Biology

FB.2 The Chemistry of Life

Conceptual Understanding: Living and non-living things are composed of elements. Elements have the unique ability to form compounds and molecules based on their atomic structures. Water has unique properties that allow it to form solutions with a variety of compounds. Living organisms are composed of biological molecules that interact with water and through chemical reactions, help to maintain homeostasis.

FB.2 **Students will demonstrate an understanding of the structure and interactions of matter and how the organization of matter supports living organisms.**

FB.2.1 *Develop and use simple atomic models to describe the components of elements (e.g., relative position, charges of protons, neutrons, and electrons).*

FB.2.2 *Obtain and use information about elements (e.g., chemical symbol, atomic number, atomic mass, and group or family) to describe the organization of the periodic table.*

FB.2.3 *Relate chemical reactivity to an element's position on the periodic table. Use this information to determine what type of bond will form between elements (ionic, covalent, hydrogen).*

FB.2.4 *Analyze and interpret data to classify common solutions as acids, bases, or neutral. Communicate the importance of pH in living systems.*

FB.2.5 *Investigate how the properties of water (e.g., cohesion, adhesion, heat capacity, solvent properties) contribute to the maintenance of living cells and organisms.*

FB.2.6 *Explain the role of the major biomolecules (carbohydrates, proteins -including enzymes, lipids, and nucleic acids) to the survival of living organisms.*

FB.2.7 ***Enrichment:** Explore the structure of biomolecules using molecular models. Relate the structure of biomolecules to their function in living things (discuss types bonding, importance of the strength and weakness of the bond in function, energy in bonds, enzyme function).*

Foundations of Biology

FB.3 Organization and Energy in Living Systems

Conceptual Understanding: Cells are the basic unit of any living organism. All organisms are composed of one (unicellular) or many cells (multicellular). Living things use their cells to acquire energy from their environment to grow and reproduce, and then they respond and adapt to that environment for survival.

FB.3 **Students will demonstrate an understanding of how the structure of living organisms supports the essential functions of life.**

FB.3.1 *Compare and contrast prokaryotic/eukaryotic and plant/animal/bacteria cells.*

FB.3.2	*Use models to investigate and explain structures within living cells that support life (e.g., cytoplasm, cell membrane, cell wall, nucleus, mitochondria, chloroplasts, lysosomes, Golgi, vacuoles, ER, ribosomes, chromosomes, centrioles, cytoskeleton, nucleolus, nuclear membrane).*
FB.3.3	*Compare and contrast active and passive cellular transport. Analyze the movement of water across a cell membrane in hypotonic, isotonic, and hypertonic solutions.*
FB.3.4	*Analyze the relationship between photosynthesis and cellular respiration and explain that relationship in terms of the need for all living things to acquire energy from their environment.*
FB 3.5	*Use models to explain how ADP and ATP cycle to store and release chemical energy using inorganic phosphate.*
FB.3.6	*Compare and contrast the processes and results of mitosis and meiosis.*
FB.3.7	***Enrichment:*** *Research and orally communicate the possible outcomes of a failure of mitosis (cancer) or meiosis (nondisjunction).*

Foundations of Biology

FB.4 Molecular Basis of Heredity

Conceptual Understanding: One strand of DNA creates a chromosome. Chromosomes have genes, which are simply segments of DNA. The information stored in DNA (in genes on chromosomes) determines the unique characteristics of an individual. DNA is the blueprint for RNA through transcription, which in turn, allows for the creation of a protein through translation. Modern technologies allow humans to manipulate DNA, RNA, and proteins to solve human dilemmas. Using technology to manipulate genetic information is controversial.

FB.4 Students will demonstrate an understanding of how genetic information is transferred from parent to offspring.

FB.4.1	*Compare and contrast the basic structure and function of nucleic acids (e.g., DNA, RNA).*
FB.4.2	*Obtain and communicate information illustrating the relationships among DNA, genes, chromosomes, and proteins to the basis of life.*
FB.4.3	*Use models (e.g., Punnett squares) and mathematical reasoning to describe and predict patterns of inheritance of single genetic traits from parents to offspring (e.g., dominant, and recessive traits, incomplete dominance, codominance, multiple alleles, sex- linkage).*
FB.4.4	*Obtain and communicate information to describe how mutations may affect genetic expression and provide examples.*
FB.4.5	*Research and report genetic technologies that may improve the quality of life (e.g., genetic engineering, cloning, gene splicing, DNA testing).*
FB.4.6	***Enrichment:*** *Debate the pros and cons of using biotechnology to manipulate genetic information for human purpose (society).*

Foundations of Biology

FB.5 Biological Evolution

Conceptual Understanding: The geologic time scale interpreted from rock strata and fossil evidence provides a way to organize major historical events in Earth's history. Rock strata can document the existence, diversity, extinction, and changes in many life forms. Adaptation by natural selection acting over generations is one important process by which species gradually change to respond to environmental pressures.

FB.5 Students will demonstrate an understanding of Earth's fossil record and its indication of the diversity of life over time.

FB.5.1 *Investigate through research the contributions of scientists to the theory of evolution and evolutionary processes (e.g., Needham, Spallanzani, Redi, Pasteur, Lyell, Lamarck, Malthus, Wallace, Darwin).*
FB.5.2 *Analyze and interpret data to support claims that different types of fossils provide evidence of the diversity of life that has existed on Earth and of the relationships between past and existing life on Earth.*
FB.5.3 *Obtain and communicate information to explain how DNA evidence and fossil records support Darwin's theory of evolution.*
FB.5.4 *Investigate how biological adaptations and genetic variations of traits in a population enhance the probability of survival in an environment (natural selection).*
FB.5.5 ***Enrichment:*** *Create and analyze models that illustrate the relatedness between all living things (cladograms/phylogenic trees).*

Foundations of Biology

FB.6 Ecological Principals

Conceptual Understanding: Ecosystems are dynamic in nature, full of complex interactions that affect the numbers and types of organisms that can survive. Biotic and abiotic factors affect ecosystems, allowing for them to sustain only a limited number of organisms and populations, known as a carrying capacity. There is a delicate balance that exists between the living and non-living things in an ecosystem. Humans can interrupt this balance, causing both local and global environmental issues.

FB.6 Students will understand the interdependence of living organisms and their environment.

FB 6.1 *Compare and contrast biotic and abiotic factors.*
FB 6.2 *Use models to analyze the cycling of matter in an ecosystem (e.g., water, carbon dioxide/oxygen, nitrogen).*
FB.6.3 *Obtain, evaluate, and communicate information to explain relationships that exist between abiotic and biotic components of an ecosystem. Explain how changes in biotic and abiotic components affect the balance of an ecosystem over time.*
FB 6.4 *Develop and use models to discuss the climate, flora, and fauna of the terrestrial and aquatic biomes of the world.*
FB 6.5 *Use models to analyze the flow of energy through food chains, webs, and pyramids.*
FB 6.6 *Engage in scientific argument from evidence to distinguish organisms that exist in symbiotic (mutualism, parasitism, commensalism) or co-evolutionary (predator-prey, cooperation, competition, and mimicry) relationships within ecosystems.*
FB 6.7 ***Enrichment:*** *Design solutions to reduce the impact of human activity on the ecosystem.*

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- Communicate scientific and/or technical information in various formats.

FOUNDATIONS OF SCIENCE LITERACY

Foundations of Science Literacy, **a one-half credit course**, is designed as an inquiry-based ACT science preparation course in which objectives from the *ACT College and Career Readiness Standards – Science* are included. The course also includes basic skills that include analyzing technical texts and graphics (charts, graphs) along with implementing engineering processes and designs to solve problems. It is recommended that Foundations of Science Literacy be taken after the successful completion of Biology.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and appropriate safety measures and practices. Students should design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students. Exemplary lessons and resources will be presented with this course to assist teachers in developing hands-on, project-based strategies for the classroom.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Foundations of Science Literacy

FSL.1 History of Science and Impacts on Society

Conceptual Understanding: The history of science is a compilation of the works of many people. To understand science and its applications, the history of scientific experiments and developments must be understood. The needs of society have been the driving force behind numerous advances in science and technology. Advances in science and technology have forever changed, and will continue to change, society.

FSL.1 Students will relate the importance of significant historical experiments and their impact on research and development.

FSL.1.1 *Trace and model the historical development of scientific ideas and theories (e.g., atomic theory, plate tectonics, evolution, genetics, discovery of cells) through the development of a timeline.*

FSL.1.2 *Research, analyze, explain, and communicate how scientific enterprise relates to society and classic inventions (e.g., microscope, telescope, computer, and telephone).*

FSL.1.3 *Identify and communicate the impact of mathematics and technology in the development of scientific thought and the practice of science (e.g., space exploration, the human genome project, and ocean exploration).*

FSL.1.4 ***Enrichment:*** *Research, analyze, explain, and communicate the influence of society, including cultural components, on the direction and progress of science and technology (e.g., medical treatments, antibiotic resistance, alternative energy development, and biomimicry).*

Foundations of Science Literacy

FSL.2 Nature of Technology and Engineering

Conceptual Understanding: Societal demands influence the need for engineering design and technology. The goal of engineering is to design and manufacture useful devices or materials (technologies) to meet societal demands. Global challenges such as climate change, medical treatments, space exploration, food supply, and clean water drive engineering design and technology development to solve societal needs and wants. Engineering practices are critical to undertaking the world's challenges. Exposure to engineering activities sparks interest in the study of science, technology, engineering, and mathematics careers.

FSL.2 **Students will identify, research, and communicate the development of technology and engineering practices.**

FSL.2.1 *Research and present a technology that was developed through engineering design. Identify its purpose, how it has advanced through alterations in design (e.g., systems that provide homes and businesses with utilities, parking structures, park and recreational structures, and traffic flow), and careers related to its use).*

FSL.2.2 *Use an engineering design process to identify a problem within the local community, and propose and develop a possible solution for that problem.**

FSL.2.3 ***Enrichment****: Use a computer simulation to model the impact of proposed solutions on a complex, real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

Foundations of Science Literacy

FSL.3 Nature of Science

Conceptual Understanding: Science is characterized by the systematic gathering of information through various forms of direct and indirect observations, and the testing of this information by methods including, but not limited to, experimentation. By formulating their own questions, planning, and conducting investigations, learners build new meaning, understanding, and knowledge of science. This helps develop their critical thinking, reasoning and decision-making skills that will serve a learner for a lifetime.

FSL.3A **Students will apply science and engineering practices and skills to scientific investigations.**

FSL.3A.1 *Ask questions and conduct research to generate a hypothesis, determine independent/dependent variables, and appropriate controls for scientific investigations and experiments.*

FSL.3A.2 *Analyze data from simple experiments and construct organized models (e.g., data tables, graphs) detailing results from the experiments.*

FSL.3A.3 *Demonstrate the proper use of safety procedures and scientific laboratory equipment. Select and use appropriate tools and instruments to collect qualitative and quantitative data.*

FSL.3A.4 *Use mathematical and computational thinking to (1) use and manipulate appropriate metric units, (2) express relationships between variables for investigations, and (3) compare or combine data from two or more simple data presentations (e.g., order or sum data from a table, categorize data from a table using a scale from another table).*

FSL.3A.5 *Analyze data sets from experiments for patterns and trends and identify any weaknesses in the experimental designs.*

Conceptual Understanding: Scientists interpret tables, graphs, and diagrams to locate data, examine relationships in the data, and extend those relationships beyond the data. Students should analyze scientific investigations and data presented in passages like those found in the science section of the ACT (e.g., Data Representation, Research Summaries, and Conflicting Viewpoint passages).

FSL.3B Students will apply scientific literacy and thinking skills to analyze and interpret data found in various graphics including, but not limited to, those found in sample ACT science passages.

FSL.3B.1 *Analyze select data from a simple and complex data presentation (e.g., charts, graphs, diagrams).*

FSL.3B.2 *Compare or combine data from two or more simple data presentations (e.g., order or sum data from a table, categorize data from a table using a scale from another table, relationships between data sets).*

FSL.3B.3 *Translate information into a table, graph, or diagram. Determine patterns, trends, and relationships as the values of variables change.*

FSL.3B.4 *Perform a simple interpolation or simple extrapolation using data in a table or graph. Determine and/or use a simple (e.g., linear) mathematical relationship that exists between data.*

FSL.3B.5 *Analyze presented information when given new information (e.g., given a new scenario, how would a given scenario be changed).*

Conceptual Understanding: Scientists understand experimental design and procedures, compare designs and procedures across experiments, and understand how changes in design and procedures affect experimental results. Students should analyze scientific investigations and data presented in passages like those found in the science section of the ACT (e.g., Data Representation, Research Summaries, and Conflicting Viewpoint passages) to understand experimental designs and procedures.

FSL.3C Students will apply scientific literacy and thinking skills to analyze scientific investigations found in various experimental designs including, but not limited to, those found in sample ACT science passages.

FSL.3C.1 *Analyze the methods and choice of tools used in simple and complex experimental designs.*

FSL.3C.2 *Determine the validity of scientific questions (e.g., hypothesis) and variables for complex experimental designs.*

FSL.3C.3 *Select and describe an alternate method for testing a hypothesis.*

FSL.3C.4 *Predict how modifying the experimental design or adding another measurement in an experimental design will affect results of the experiment.*

FSL.3C.5 *Determine which additional trials could be performed in an investigation to enhance the results of an experimental design.*

Conceptual Understanding: Scientists evaluate multiple explanations for the same phenomena to determine their differences, similarities, strengths, and weaknesses, and evaluating the validity of conclusions based on experimental results. They evaluate the validity of conclusions based on experimental results. Students should analyze scientific investigations and data presented in passages like those found in the science section of the ACT (e.g., Data Representation, Research Summaries, and Conflicting Viewpoint passages) to evaluate scientific explanations.

FSL.3D Students will apply scientific literacy and thinking skills to evaluate theoretical models, inferences, and experimental results found in various experimental designs including, but not limited to, those found in sample ACT science passages.

FSL.3D.1 *Select the hypothesis, prediction, or conclusion that is, or is not, supported by data presentation or pieces of informational text.*
FSL.3D.2 *Determine whether given information supports or contradicts a hypothesis or conclusion, and provide support for the reasoning.*
FSL.3D.3 *Analyze and interpret data from informational texts and data to (1) reveal patterns and construct meaning (2) support or refute hypotheses, explanations, claims or designs, or (3) evaluate the strength of conclusions.*
FSL.3D.4 *Use new information to make a prediction based on a theoretical model.*
FSL.3D.5 *Select and explain why a hypothesis, prediction, or conclusion is, or is not, supported by two or more data presentations or theoretical models.*

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

GENETICS

Genetics, **a one-half credit course,** is a laboratory-based course that explores the principles of classical and molecular genetics. The structure and function relationship of DNA forms the foundation for the study of DNA inheritance, RNA and protein production, and the resulting phenotypes in organisms. Classical Mendelian genetics is explored to analyze patterns of inheritance and genetic variability within populations. Multiple applications of biotechnology are investigated to address a variety of problems in modern society.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, lab experiences, and scientific research (projects) for a minimum of 30% of the class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Genetics

GEN.1 Structure and Function of DNA

Conceptual Understanding: Chromosomes, the carriers of genetic information, are composed of both DNA and proteins. A significant body of evidence generated through multiple experiments by many scientists led to the conclusion that DNA is the universal genetic material. Once this was established, efforts focused on deciphering the structure of DNA and the mechanism through which DNA is passed on to cells with little to no errors. These discoveries formed the foundation of modern molecular genetics.

GEN.1A Students will demonstrate that all cells contain genetic material in the form of DNA.

GEN.1A.1 *Model the biochemical structure, either 3-D or computer-based, of DNA based on the experimental evidence available to Watson and Crick (Chargaff, 1950; Franklin, 1951).*

GEN.1A.2 *Explain the importance of the historical experiments that determined that DNA is the heritable material of the cell (Griffith, 1928; Avery, McCarty & MacLeod, 1944; Hershey & Chase, 1952).*

GEN.1A.3 *Relate the structure of DNA to its specific functions within the cell.*

GEN.1A.4 *Conduct a standard DNA extraction protocol using salt, detergent, and ethanol from various cell types (e.g., plant, animal, fungus). Compare and contrast the consistency and quantity of DNA extracted from various cell types.*

GEN.1A.5 ***Enrichment:*** *Use an engineering design process to refine the methodology to optimize the DNA-extraction process for various cell types.**

GEN.1A.6 *Investigate the structural differences between the genomes (i.e., circular/linear chromosomes and plasmids) found in prokaryotes and eukaryotes.*

Conceptual Understanding: Before a cell divides, the DNA sequence of its chromosomes is replicated, and each daughter cell receives a copy. In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.

GEN.1B Students will analyze how the DNA sequence is copied and transmitted to new cells.

GEN.1B.1 *Compare and contrast various proposed models of DNA replication (i.e., conservative, semi-conservative, and disruptive). Evaluate the evidence used to determine the mechanism of DNA replication.*
GEN.1B.2 *Develop and use models to illustrate the mechanics of DNA replication.*
GEN.1B.3 *Microscopically observe and analyze the stages of the cell cycle (G_1-S-G_2-M) to describe the phenomenon, and identify methods at different cell cycle checkpoints through which the integrity of the DNA code is maintained.*

Genetics

GEN.2 Transcription, Translation, and Mutations

Conceptual Understanding: The genetic information stored in the DNA molecule is expressed to produce a protein and result in the formation of an observable trait, or phenotype, in the organism. Gene expression leads to protein production through the processes of transcription in the nucleus and translation in the ribosome.

GEN.2A Students will analyze and explain the processes of transcription and translation in protein production.

GEN.2A.1. *Compare and contrast the structure of RNA to DNA and relate this structure to the different function of each molecule.*
GEN.2A.2 *Describe and model how the process of transcription produces RNA from a DNA template in both prokaryotes and eukaryotes.*
GEN.2A.3 *Develop a model to show the relationship between the components involved in the mechanics of translation at the ribosome.*
GEN.2A.4 Analyze the multiple roles of RNA in translation. Compare the structure and function of tRNA, rRNA, mRNA, and snRNA.
GEN.2A.5 ***Enrichment:*** *Evaluate Beadle and Tatum's "One Gene-One Enzyme Hypothesis" (1941) in the development of the central dogma (DNA →RNA →Protein). Explain how new discoveries, such as alternate splicing of introns, have led to the revision of the central dogma.*

Conceptual Understanding: Mutations may result in the formation of new gene alleles, alter protein structure, and produce new phenotypes.

GEN.2B Students will determine the causes and effects of mutations in DNA.

GEN.2B.1 *Identify factors that cause mutations (e.g., environmental, errors in replication, and viral infections).*
GEN.2B.2 *Explain how these mutations may result in changes in protein structure and function.*
GEN.2B.3 *Describe cellular mechanisms that can help to minimize mutations (e.g., cell cycle checkpoints, DNA polymerase proofreading, and DNA repair enzymes).*
GEN.2B.4 *Investigate the role of mutations and the loss of cell cycle regulation in the development of cancers.*

GEN.2B.5 ***Enrichment:*** *Use an engineering design process to research the current status of genetic technology and personalized medicine, then propose and test targeted medical or forensic applications.**

Genetics

GEN.3 Biotechnological Applications

Conceptual Understanding: The application of modern molecular genetics led to the development of recombinant DNA technology and the subsequent explosion of biotechnology applications. Biotechnology and the use of genetically modified organisms have altered many aspects of daily life, including forensics, agriculture, and medicine.

GEN.3 Students will investigate biotechnology applications and bioengineering practices.

GEN.3.1 *Explain and demonstrate the use of various tools and techniques of DNA manipulation and their applications in forensics (e.g., paternity and victim/suspect identification), agriculture (e.g., pesticide or herbicide resistance, improved yields, and improved nutritional value), and personalized medicine (e.g., targeted therapies, cancer treatment, production of insulin and human growth hormone, and engineering insect vectors of human parasites).*

GEN.3.2 *Experimentally demonstrate genetic transformation, protein purification, and/or gel electrophoresis.*

GEN.3.3 ***Enrichment:*** *Use an engineering design process to refine methodology and optimize the process of genetic transformation, protein purification, and/or gel electrophoresis.**

GEN.3.4 ***Enrichment:*** *Develop logical arguments based on scientific evidence for and against ethical concerns regarding biotechnology/bioengineering.*

Genetics

GEN.4 Classic Mendelian Genetics

Conceptual Understanding: Gregor Mendel is known as the "Father of Genetics" due to his work with pea plants, which established that traits are passed from parents to offspring in predictable ways. Mendel's findings formed the foundation from which geneticists can determine the mode of inheritance of various traits (e.g., dominant, recessive, and codominant).

GEN.4 Students will analyze and interpret data collected from probability calculations to explain the inheritance of traits within a population.

GEN.4.1 *Demonstrate Mendel's law of dominance and segregation using mathematics to predict phenotypic and genotypic ratios.*

GEN.4.2 *Illustrate Mendel's law of independent assortment by analyzing multi-trait cross data sets for patterns and trends.*

GEN.4.3 *Investigate traits that follow non-Mendelian inheritance patterns (e.g., incomplete dominance, codominance, multiple alleles, autosomal linkage, sex-linkage, polygenic, and epistasis).*

GEN.4.4 *Construct pedigrees from observed phenotypes. Analyze and interpret data to determine patterns of inheritance and disease risk.*

GEN.4.5 ***Enrichment:*** *Construct maps of genes on a chromosome based on data obtained from 2- and/or 3- point crosses or from recombination frequencies.*

Genetics

GEN.5 Population Genetics

Conceptual Understanding: Most species display considerable amounts of genetic variation. The variation is represented as differences in allele frequencies within the gene pool of populations of a species. Variations in the structure of gene pools form the basis of evolutionary change.

GEN.5 Students will apply population genetic concepts to explain variability of organisms within a population.

GEN.5.1 *Model the inheritance of chromosomes through meiotic cell division and demonstrate how meiosis and sexual reproduction lead to genetic variation in populations.*

GEN.5.2 *Explain how natural selection acts upon genetic variability within a population and may lead to changes in allelic frequencies over time and evolutionary changes in populations.*

GEN.5.3 *Describe processes that cause changes in allelic frequencies (e.g., nonrandom mating, small population size, immigration and emigration, genetic drift, and mutation).*

GEN.5.4 *Apply the Hardy-Weinberg formula to analyze changes in allelic frequencies due to natural selection in a population. Relate these changes to the environmental fitness of the phenotypes.*

GEN.5.5 ***Enrichment:*** *Analyze computer simulations of the effects of natural selection on allelic frequencies in a population.*

GEN.5.6 ***Enrichment:*** *Apply the concept of natural selection to analyze differences in human populations (e.g., skin color, lactose persistence, sickle cell anemia, and malaria).*

GEN.5.7 ***Enrichment:*** *Use genomic databases for sequence analysis and apply the information to species comparisons, evolutionary relationships, and/or determine the molecular basis of inherited disorders.*

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- Identify dependent and independent variables and appropriate controls.
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- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

HUMAN ANATOMY AND PHYSIOLOGY

Human Anatomy and Physiology, **a one-credit course**, is a laboratory-based course that investigates the structures and functions of the human body. Core content emphasizes the structure and function of cells, tissues, and organs; organization of the human body and its biochemical composition; the skeletal, muscular, nervous, endocrine, digestive, respiratory, cardiovascular, integumentary, immune, urinary, and reproductive systems; and the impact of diseases on certain systems. Laboratory activities, research, the use of technology, and the effective communication of results through various methods are integral components of this course. It is recommended that Human Anatomy and Physiology be taken after successful completion of Biology.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, lab experiences, and scientific research (projects) for a minimum of 30% of the class time.

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Human Anatomy and Physiology

HAP.1 Physiological Functions/Anatomical Structure

Conceptual Understanding: Anatomists have developed a universal set of reference terms that aid in the identification of body structures with a high degree of specificity. Body organization from simple to complex levels and an introduction to the organ systems forming the body lead to a higher understanding of anatomical structures in the human body.

HAP.1 Students will demonstrate an understanding of how anatomical structures and physiological functions are organized and described using anatomical position.

HAP.1.1 *Apply appropriate anatomical terminology when explaining the orientation of regions, directions, and body planes or sections.*
HAP.1.2 *Locate organs and their applicable body cavities and systems.*
HAP.1.3 *Investigate the interdependence of the various body systems to each other and to the body as a whole.*

Human Anatomy and Physiology

HAP.2 Cells and Tissues

Conceptual Understanding: The smallest structural and functional unit of the human body is the cell. The cell is composed of organelles that perform varied but specific functions. Cells within the human body can metabolize, digest foods, dispose of waste, reproduce, grow, move, and respond to stimuli. Groups of cells that are similar in structure and function form the four types of tissues (epithelial, connective, nervous, and muscle) found in the human body.

HAP.2 Students will demonstrate an understanding of the relationship of cells and tissues that form complex structures of the body.

HAP.2.1 *Analyze the characteristics of the four main tissue types: epithelial, connective, muscle, and nervous. Examine tissues using microscopes and other various technologies.*
HAP.2.2 *Construct a model to demonstrate how the structural organization of cells in a tissue relates to the specialized function of that tissue.*
HAP.2.3 ***Enrichment:*** *Use an engineering design process to research and develop medications (i.e., targeted cancer therapy drugs) that target uncontrolled cancer cell reproduction.**

Human Anatomy and Physiology

HAP.3 Integumentary System

Conceptual Understanding: The integumentary system is composed of epithelial membranes (i.e., skin epidermis, mucosae, and serosae). The connective-tissue synovial membranes cover, insulate, protect, and cushion body organs as well as the entire body. The integumentary system is critical to maintaining homeostasis using internal and external regulators.

HAP.3 Students will investigate the structures and functions of the integumentary system, including the cause and effect of diseases and disorders.

HAP.3.1 *Identify structures and explain the functions of the integumentary system, including layers of skin, accessory structures, and types of membranes.*
HAP.3.2 *Investigate specific mechanisms (e.g., feedback and temperature regulation) through which the skin maintains homeostasis.*
HAP.3.3 *Research and analyze the causes and effects of various pathological conditions (e.g., burns, skin cancer, bacterial/viral infections, and chemical dermatitis).*
HAP.3.4 ***Enrichment:*** *Use an engineering design process to design and model/simulate effective treatments for skin disorders (e.g., tissue grafts).**

Human Anatomy and Physiology

HAP.4 Skeletal System

Conceptual Understanding: The skeletal system is composed of cartilage and bone. Together these supportive tissues form the framework for the body. The skeletal system encloses organs, attaches skeletal muscles, and connects bone, forming joints to aid in movement.

HAP.4 Students will investigate the structures and functions of the skeletal system including the cause and effect of diseases and disorders.

HAP.4.1 *Use models to compare the structure and function of the skeletal system.*

HAP.4.2 *Develop and use models to identify and classify major bones as part of the appendicular or axial skeleton.*
HAP.4.3 *Identify and classify types of joints and their movement.*
HAP.4.4 *Demonstrate an understanding of the growth and development of the skeletal system, differentiating between endochondral and intramembranous ossification.*
HAP.4.5 *Construct explanations detailing how mechanisms (e.g., Ca^{2+} regulation) are used by the skeletal system to maintain homeostasis.*
HAP.4.6 *Research and analyze various pathological conditions (e.g., bone fractures, osteoporosis, bone cancers, various types of arthritis, and carpal tunnel syndrome).*
HAP.4.7 ***Enrichment:*** *Use an engineering design process to develop, model, and test effective treatments for bone disorders (i.e., prosthetics).**

Human Anatomy and Physiology

HAP.5 Muscular System

Conceptual Understanding: The muscular system, with the aid of three types of muscle tissue (skeletal, cardiac, and smooth), provides movement, contour and shape, joint stability, heat generation, and the transportation of materials throughout the body.

HAP.5 Students will investigate the structures and functions of the muscular system, including the cause and effect of diseases and disorders.

HAP.5.1 *Develop and use models to illustrate muscle structure, muscle locations and groups, actions, origins, and insertions.*
HAP.5.2 *Describe the structure and function of the skeletal muscle fiber and the motor unit.*
HAP.5.3 *Explain the molecular mechanism of muscle contraction and relaxation.*
HAP.5.4 *Use models to locate the major muscles and investigate the movements controlled by each muscle.*
HAP.5.5 *Compare and contrast the anatomy and physiology of the three types of muscle tissue.*
HAP.5.6 *Use technology to plan and conduct an investigation that demonstrates the physiology of muscle contraction, muscle fatigue, or muscle tone. Collect and analyze data to interpret results, then explain and communicate conclusions.*
HAP.5.7 *Research and analyze the causes and effects of various pathological conditions, (e.g., fibromyalgia, muscular dystrophy, cerebral palsy, muscle cramps/strains, and tendonitis).*
HAP.5.8 ***Enrichment:*** *Use an engineering design process to develop effective ergonomic devices to prevent muscle fatigue and strain (e.g., carpal tunnel, exoskeletons for paralysis, or training plans to prevent strains/sprains/cramps).**

Human Anatomy and Physiology

HAP.6 Nervous System

Conceptual Understanding: The nervous system is composed of the central nervous system and the peripheral nervous system. These divisions work together to create every thought, action, and sensation that occurs within the body. The exploration of the special senses will provide an understanding of sight, hearing, smell, and taste.

HAP. 6 Students will investigate the structures and functions of the nervous system, including the cause and effect of diseases and disorders.

HAP.6.1 *Describe and evaluate how the nervous system functions and interconnects with all other body systems.*

HAP.6.2 *Analyze the structure and function of neurons and their supporting neuroglia cells (e.g. astrocytes, oligodendrocytes, Schwann cells, microglial).*

HAP.6.3 *Discuss the structure and function of the brain and spinal cord.*

HAP.6.4 *Compare and contrast the structures and functions of the central and peripheral nervous systems. Investigate how the systems interact to maintain homeostasis (e.g., reflex responses, sensory responses).*

HAP.6.5 ***Enrichment:*** *Plan and conduct an experiment to test reflex response rates under varying conditions. Using technology, construct graphs in order to analyze and interpret data to explain and communicate conclusions.*

HAP.6.6 *Describe the major characteristics of the autonomic nervous system. Contrast the roles of the sympathetic and parasympathetic nervous systems in maintaining homeostasis.*

HAP.6.7 *Describe the structure and function of the special senses (i.e., vision, hearing, taste, and olfaction).*

HAP.6.8 *Research and analyze the causes and effects of various pathological conditions (e.g., addiction, depression, schizophrenia, Alzheimer's, sports-related chronic traumatic encephalopathy [CTE], dementia, chronic migraine, stroke, and epilepsy).*

HAP.6.9 ***Enrichment:*** *Use an engineering design process to develop, model, and test preventative devices for neurological injuries and/or disorders (e.g., concussion-proof helmets or possible medications for addiction and depression).**

Human Anatomy and Physiology

HAP.7 Endocrine System

Conceptual Understanding: The endocrine system, using hormones, gives instructions that control growth and development, reproductive capabilities, and the physiological homeostasis of the body systems.

HAP.7 Students will demonstrate an understanding of the major organs of the endocrine system and the associated hormonal production and regulation.

HAP.7.1 *Obtain, evaluate, and communicate information to illustrate that the endocrine glands secrete hormones that help the body maintain homeostasis through feedback mechanisms.*

HAP.7.2 *Discuss the function of each endocrine gland and the various hormones secreted.*

HAP.7.3 *Model specific mechanisms through which the endocrine system maintains homeostasis (e.g., insulin/glucagon and glucose regulation;* T_3 / T_4 *and metabolic rates; calcitonin/parathyroid and calcium regulation; antidiuretic hormone and water balance; growth hormone; and cortisol and stress).*

HAP.7.4 *Research and analyze the effects of various pathological conditions (e.g., diabetes mellitus, pituitary dwarfism, Graves' disease, Cushing's syndrome, hypothyroidism, and obesity).*

HAP.7.5 ***Enrichment:*** *Use an engineering design process to develop effective treatments for endocrine disorders (e.g., methods to regulate hormonal imbalance).**

Human Anatomy and Physiology

HAP.8 Male and Female Reproductive Systems

Conceptual Understanding: The reproductive system's biological function is to generate offspring for the continuance of our species. Interactions of the egg and sperm, the biological clock, and fertility play critical roles in the production of an offspring. Proper embryonic development directly depends on the health of the reproductive system.

HAP. 8 Students will investigate the structures and functions of the male and female reproductive system, including the cause and effect of diseases and disorders.

HAP.8.1 *Compare and contrast the structure and function of the male and female reproductive systems.*
HAP.8.2 *Describe the male reproductive anatomy and relate structure to sperm production and release.*
HAP.8.3 *Describe the female reproductive anatomy and relate structure to egg production and release.*
HAP.8.4 *Construct explanations detailing the role of hormones in the regulation of sperm and egg development. Analyze the role of negative feedback in regulation of the female menstrual cycle and pregnancy.*
HAP.8.5 *Evaluate and communicate information about various contraceptive methods to prevent fertilization and/or implantation.*
HAP.8.6 *Describe the changes that occur during embryonic/fetal development, birth, and the growth and development from infancy, childhood, and adolescence to adult.*
HAP.8.7 *Research and analyze the causes and effects of various pathological conditions (e.g., infertility, ovarian cysts, endometriosis, sexually transmitted diseases, and ectopic pregnancy). Research current treatments for infertility.*

Human Anatomy and Physiology

HAP.9 Blood

Conceptual Understanding: Blood is the necessary fluid that transports oxygen and other elements throughout the body and removes waste products. Blood's unique composition allows for grouping into four major blood type groups (A, B, AB, and O). Blood types are based on the presence or absence of inherited antigens on the surface of the red blood cells.

HAP.9 Students will analyze the structure and functions of blood and its role in maintaining homeostasis.

HAP.9.1 *Describe the structure, function, and origin of the cellular components and plasma components of blood.*
HAP.9.2 *Distinguish the cellular difference between the ABO blood groups and investigate blood type differences utilizing antibodies to determine compatible donors and recipients.*
HAP.9.3 *Research and analyze the causes and effects of various pathological conditions (e.g., anemia, malaria, leukemia, hemophilia, and blood doping).*
HAP.9.4 ***Enrichment:*** *Use an engineering design process to develop effective treatments for blood disorders (e.g., methods to regulate blood cell counts or blood doping tests).**

Human Anatomy and Physiology

HAP.10 Cardiovascular System

Conceptual Understanding: The cardiovascular system is composed of the heart and blood vessels. The heart is the mechanism that cycles the blood throughout the body via the blood vessels. Using blood as a carrier, the system transports nutrients, gases, wastes, antibodies, electrolytes, and many other substances to and from the cells of the body. The location, size, and orientation of the heart, blood vessels, veins, arteries, and capillaries are essential in maintaining cardiovascular health. Maintenance of this system is vital.

HAP.10 Students will investigate the structures and functions of the cardiovascular system, including the cause and effect of diseases and disorders.

HAP.10.1 *Design and use models to investigate the functions of the organs of the cardiovascular system.*
HAP.10.2 *Describe the flow of blood through the pulmonary system and systemic circulation.*
HAP.10.3 *Investigate the structure and function of different types of blood vessels (e.g., arteries, capillaries, veins). Identify the role each plays in the transport and exchange of materials.*
HAP.10.4 *Demonstrate the role of valves in regulating blood flow.*
HAP.10.5 *Plan and conduct an investigation to test the effects of various stimuli on heart rate and/or blood pressure. Construct graphs to analyze data and communicate conclusions.*
HAP.10.6 *Research and analyze the effects of various pathological conditions (e.g., hypertension, myocardial infarction, mitral valve prolapse, varicose veins, and arrhythmia).*
HAP.10.7 ***Enrichment:*** *Use an engineering design process to develop, model, and test effective treatments for cardiovascular diseases (e.g., methods to regulate heart rate, artificial replacement valves, open blood vessels, or strengthening leaky valves).**

Human Anatomy and Physiology

HAP.11 Lymphatic System

Conceptual Understanding: The lymphatic system is composed of lymphoid vessels and organs. These vessels assist the cardiovascular system by maintaining blood volume. The lymphoid organs defend the body from pathogens by providing sites for development and maturation of immune system cells. There are multiple disorders of the immune system affecting the human population.

HAP. 11 Students will investigate the structures and functions of the lymphatic system, including the cause and effect of diseases and disorders.

HAP.11.1 *Analyze the functions of leukocytes, lymph, and lymphatic organs in the immune system.*
HAP.11.2 *Compare the primary functions of the lymphatic system and its relationship to the cardiovascular system.*
HAP.11.3 *Compare and contrast the body's non-specific and specific lines of defense, including an analysis of the roles of various leukocytes: basophils, eosinophils, neutrophils, monocytes, and lymphocytes.*
HAP.11.4 *Correlate the functions of the spleen, thymus, lymph nodes, and lymphocytes to the development of immunity.*
HAP.11.5 *Differentiate the role of B-lymphocytes and T-lymphocytes in the development of humoral and cell-mediated immunity and primary and secondary immune responses.*
HAP.11.6 *Investigate various forms of acquired and passive immunity (e.g., fetal immunity, breastfed babies, vaccinations, and plasma donations).*
HAP.11.7 *Research and analyze the causes and effects of various pathological conditions (e.g., viral infections, auto-immune disorders, immunodeficiency disorders, and lymphomas).*

Human Anatomy and Physiology

HAP.12 Respiratory System

Conceptual Understanding: The respiratory system provides the body with an abundant and continuous supply of oxygen and removes carbon dioxide from the body. The organs of this system include the nose, pharynx, larynx, trachea, bronchi and their smaller branches, and the lungs. The interaction of these organs with the cardiovascular system transports respiratory gases to the tissue cells throughout the body. Interruptions in the mechanics of this system will lead to respiratory distress.

HAP. 12 Students will investigate the structures and functions of the respiratory system, including the cause and effect of diseases and disorders.

HAP.12.1 *Design and use models to illustrate the functions of the organs of the respiratory system.*
HAP.12.2 *Describe structural adaptations of the respiratory tract and relate these structural features to the function of preparing incoming air for gas exchange at the alveolus.*
HAP.12.3 *Identify the five mechanics of gas exchange: pulmonary ventilation, external respiration, transport gases, internal respiration, and cellular respiration.*
HAP.12.4 ***Enrichment:*** *Use an engineering design process to develop a model of the mechanisms that support breathing, and illustrate the inverse relationship between volume and pressure in the thoracic cavity.**
HAP.12.5 *Research and analyze the causes and effects of various pathological conditions (e.g., asthma, bronchitis, pneumonia, and COPD).*
HAP.12.6 *Research and discuss new environmental causes of respiratory distress (e.g., e-cigarettes, environmental pollutants, and changes in inhaled gas composition).*

Human Anatomy and Physiology

HAP.13 Digestive System

Conceptual Understanding: The digestive system processes food so that it can be absorbed and used by the body's cells. The organs of the system are responsible for food ingestion, digestion, absorption, and elimination of the undigested remains from the body.

HAP.13 Students will investigate the structures and functions of the digestive system, including the cause and effect of diseases and disorders.

HAP.13.1 *Analyze the structure-function relationship in organs of the digestive system.*
HAP.13.2 *Use models to describe structural adaptations present in each organ of the tract and correlate the structures to specific processing of food at each stage (e.g., types of teeth; muscular, elastic wall and mucous lining of the stomach; villi and microvilli of the small intestine; and sphincters along the digestive tract).*
HAP.13.3 *Identify the accessory organs (i.e., salivary glands, liver, gallbladder, and pancreas) for digestion and describe their function.*
HAP.13.4 *Plan and conduct an experiment to illustrate the necessity of mechanical digestion for efficient chemical digestion.*
HAP.13.5 *Research and analyze the activity of digestive enzymes within different organs of the digestive tract, connecting enzyme function to environmental factors such as pH.*
HAP.13.6 *Evaluate the role of hormones (i.e., gastrin, leptin, and insulin) in the regulation of hunger and satiety/fullness.*
HAP.13.7 *Research and analyze the causes and effects of various pathological conditions (e.g., GERD/acid reflux, stomach ulcers, lactose intolerance, irritable bowel syndrome, gallstones, appendicitis, and hormonal imbalances and obesity).*
HAP.13.8 ***Enrichment:*** *Use an engineering design process to develop effective treatments for gastrointestinal diseases (e.g., methods to regulate stomach acids or soothe ulcers, treat food intolerance, and dietary requirements/modifications).**

Human Anatomy and Physiology

HAP.14 Urinary System

Conceptual Understanding: The urinary system regulates the body's homeostasis by removing nitrogenous wastes while maintaining water balance, electrolytes, and the blood's acid/base balance within the body. The kidney is the primary filtration and reabsorption organ of the urinary system, controlling the composition of urine and, in turn, regulating blood composition. Improper function of the kidneys could lead to death if not corrected.

HAP.14 Students will investigate the structures and functions of the urinary system, including the cause and effect of diseases and disorders.

HAP.14.1 *Understand the structure and function of the urinary system in relation to maintenance of homeostasis.*
HAP.14.2 *Describe the processes of filtration and selective reabsorption within the nephrons as it relates to the formation of urine and excretion of excess materials in the blood.*
HAP.14.3 *Investigate relationship between urine composition and the maintenance of blood sugar, blood pressure, and blood volume.*
HAP.14.4 ***Enrichment:*** *Conduct a urinalysis to compare the composition of urine from various "patients."*
HAP.14.5 *Develop and use models to illustrate the path of urine through the urinary tract.*
HAP.14.6 *Research and analyze the causes and effects of various pathological conditions and other kidney abnormalities (e.g., kidney stones, urinary tract infections, gout, dialysis, and incontinence).*

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

MARINE AND AQUATIC SCIENCE I
MARINE AND AQUATIC SCIENCE II

Marine and Aquatic Science I, **a one-half credit course**, and Marine and Aquatic Science II, **a one-half credit course,** are laboratory-based courses that investigate the biodiversity of salt water and fresh water organisms, including their interactions with the physical and chemical environment. Science and engineering practices, cross-cutting concepts, nature of science, and technology are incorporated into the standards. Special emphases relating to human impacts and career opportunities are integral components of this course. Marine and Aquatic Science I must be taken before Marine and Aquatic Science II. It is recommended that Marine and Aquatic Science I and II be taken after the successful completion of Biology.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a lab-based course, students are expected to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, lab experiences, and scientific research (projects) for a minimum of 30% of the class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Marine and Aquatic Science I

MAQ.1 Water Properties and Quality

Conceptual Understanding: Water is essential to all life on earth. The chemical and physical properties of water allow for all essential processes with biota. Analysis of water quality indicates ecosystem health and balance. Recycling of water throughout the biosphere allows for replenishment of fresh water, but contaminations by human activities are hindering the total amount of potable fresh water.

MAQ.1 Students will develop an understanding of the unique physical and chemical properties of water and how those properties shape life on earth.

MAQ.1.1 *Characterize the physical and chemical properties of water, including specific heat, surface temperature, universal solvent, and hydrogen bonding between water molecules (i.e., cohesion/adhesion/capillary action).*

MAQ.1.2 *Describe the role of water within biological systems (e.g., provides the medium necessary to allow for life processes such as protein synthesis, enzymatic reactions, and passive transport).*

MAQ.1.3 *Diagram, utilizing digital or physical models, the water cycle and how it relates to the total amount of fresh water available to living things at any given time.*

MAQ.1.4 *Collect, analyze, and communicate quantitative data that includes dissolved oxygen, pH, temperature, salinity, mineral content, nitrogen compounds, and turbidity from an aquatic environment (i.e., hydrometer, refractometer, Secchi disk, and chemical test kits).*

MAQ.1.5 *Research, analyze, and communicate current technology and career opportunities available to collect this data on a global scale using CTD, buoy data, or satellites.*

MAQ.1.6 ***Enrichment:*** *Use an engineering design process to reduce the effects of pollution in aquatic ecosystems (e.g., microplastics, garbage patches, oil spills, and eutrophication). Students will design a proposed solution based on current research and/or observations, and develop a model in order to test their design. Data from experimentation will be analyzed, organized graphically, and communicated to classmates to determine the effectiveness of the proposed solution.**

Marine and Aquatic Science I

MAQ.2 Fluid Dynamics

Conceptual Understanding: Fluid dynamics include properties and features of waves, currents, and tides. Each of these is vital for uniformity of temperature and chemical balance within ecosystems. Physical changes can be attributed to the movement of water, including shoreline development, erosion, and island formation. Climate change is influencing changes in our present fluid dynamic models.

MAQ.2 Students will develop an understanding of the principles of fluid dynamics as it relates to both salt and freshwater systems.

MAQ.2.1 *Characterize wave features and wave properties, including wavelength, period, wave speed, breakers, and constructive waves and their effects on shoreline communities (e.g., headlands, embayments, shoreline erosion, and deposition).*

MAQ.2.2 *Survey predictable patterns of tides (i.e., tidal period and range, diurnal, semidiurnal, mixed, spring, and neap tides) to correlate with moon phases in graphical form.*

MAQ.2.3 *Summarize principles related to currents (e.g., global wind patterns, Coriolis effect, Ekman spiral, surface, thermohaline, upwelling, downwelling, El Niño, La Niña, hurricanes, Barrier Island movement).*

MAQ.2.4 *Research, analyze, and communicate scientific arguments to support climate models that predict how global and regional climate change can affect Earth's systems (e.g., precipitation and temperature and their associated impacts on sea level, global ice volumes, and atmosphere and ocean composition).*

MAQ.2.5 *Distinguish among lentic and lotic water systems, including water flow, seasonal overturn, and watershed mapping.*

Marine and Aquatic Science I

MAQ.3 Geological Features

Conceptual Understanding: Plate tectonics explain present geological features that can be described in different aquatic ecosystems. Natural phenomena, such as sea floor spreading, are caused by plate tectonic action. The distance from shoreline and availability of light classifies different areas of the ocean.

MAQ.3 Students will understand the principles of plate tectonics, sea floor spreading, and physical features of oceanic zones.

MAQ.3.1 *Use geospatial data to analyze, explain, and communicate differences among the major geological features of specific aquatic ecosystems (e.g., plate tectonics, continental rise, continental slope, abyssal plain, trenches, sea mounts, island formation, and watersheds).*

MAQ.3.2 *Develop an understanding of plate tectonics to predict certain geological features (e.g., sea floor spreading, paleomagnetic measurements, and orogenesis).*

MAQ.3.3 *Classify zones of the ocean based on distance from shorelines (i.e., intertidal, neritic, oceanic, and benthic zones), temperature, and light availability (i.e., epipelagic, mesopelagic, bathypelagic, abyssopelagic, and hadopelagic).*

MAQ.3.4 *Classify zones of freshwater sources based on the velocity of current, depth, and temperature.*

Marine and Aquatic Science I

MAQ.4 Flora and Fauna

Conceptual Understanding: Unique flora and fauna can be found in different aquatic ecosystems. Their features and unique biochemistry may serve to further the human quality of life. However, human impacts and natural events have altered many of these ecosystems in different ways.

MAQ.4 Students will examine characteristics of specific aquatic ecosystems and the effects of human and natural phenomena on those ecosystems.

MAQ.4.1 *Compare and contrast the unique biotic and abiotic characteristics of the following selected aquatic ecosystems: intertidal zone, wetlands/estuaries, coral reef, barrier islands, continental slope/shelf, abyss, rivers/streams/watersheds, and lakes/ponds.*

MAQ.4.2 *Recognize representative examples of plants and animals that would be specifically adapted to the aquatic ecosystems, and identify adaptations necessary to survive.*

MAQ.4.3 *Determine the niches within trophic levels in the aquatic ecosystems by creating food webs and researching the symbiotic relationships that exist.*

MAQ.4.4 *Research, analyze, and communicate the effects of urbanization and continued expansion by humans on the aquatic ecosystems' biodiversity (e.g., land use changes, erosion and sedimentation, over-fishing, invasive/exotic species, and pollution).*

MAQ.4.5 *Explore the importance of species diversity to the biological resources needed by human populations, including food (e.g., aquaculture and mariculture), medicine, and natural aesthetics.*

MAQ.4.6 *Research, analyze, and communicate the effects of natural phenomena (e.g., hurricanes, floods, drought, and sea-level rise) on the aquatic ecosystems.*

MAQ.4.7 *Research, analyze, and communicate which and in what capacity local, state, and federal regulatory agencies are involved in different aquatic ecosystems, including current environmental policies already in place (e.g., the Clean Water Act and the Endangered Species Act). Research should include, but is not limited to, how humans can preserve animal diversity through the use of habitat creation and conservation, research, legislation, medical and breeding programs, and management of genetic diversity at local and global levels.*

MAQ.4.8 ***Enrichment:*** *Choose an environmental issue that currently exists in one of the aquatic ecosystems and use an engineering design process to propose and develop a possible solution using scientific knowledge and best management practices (BMPs). Create an environmental action plan to include moral, legal, societal, political, and economic decisions that impact animal diversity in both the short and long term. Results from developed plans will be communicated with classmates.**

Marine and Aquatic Science II

MAQ.5 Primary Producers

Conceptual Understanding: Primary producers are the basis of every food web in aquatic ecosystems. While many producers are photosynthetic autotrophs, chemosynthesis is also a common form of energy conversion. Surveying shared and derived characteristics of producers demonstrates evolutionary development. Various methods are currently utilized to measure primary productivity in various ecosystems.

MAQ.5 Students will explore the biodiversity and interactions among aquatic life.

MAQ.5.1 *Survey common primary producers and their roles in primary production in relation to geographical distribution within various aquatic ecosystems.*

MAQ.5.2 *List and describe common autotrophs that may be found in particular aquatic ecosystems, including prokaryotes (e.g., Cyanobacteria and Archaebacteria), protists (e.g., diatoms, dinoflagellates, green algae, kelp, sargassum, and red algae), and plants (e.g., cord grasses, reeds, seagrasses, and mangroves).*

MAQ.5.3 *Recognize characteristics that are shared and derived using graphical representations of primary-producer evolution and develop cladograms/phylogenetic trees.*

MAQ.5.4 *Use dichotomous keys to identify sample producers within an aquatic ecosystem.*

MAQ.5.5 *Paraphrase energy conversion processes (e.g., photosynthesis and chemosynthesis).*

MAQ.5.6 ***Enrichment:*** *Research, analyze, and communicate historical and current methodologies for measuring primary productivity. Use an engineering design process to design and develop improvements to measure primary productivity (e.g., the light and dark bottle method and satellite data).**

Marine and Aquatic Science II

MAQ.6 Invertebrate Consumers

Conceptual Understanding: Many consumers found within aquatic ecosystems range from single-celled protozoa to multicellular invertebrates. While many of these consumers share basic morphological characteristics, derived characters demonstrate evolutionary relationships. Varied adaptations are found among these organisms for successful niches within selected ecosystems.

MAQ.6 Students will investigate characteristics of aquatic invertebrates.

MAQ.6.1 *Characterize aquatic representatives of the following taxa: Protozoa (e.g., foraminiferians, radiolarians, amoeba, and paramecium), Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Rotifera, Mollusca, Arthropoda, Bryozoa, Brachiopoda, and Echinodermata.*

MAQ.6.2 *Identify characteristics that are shared and derived using graphical representations of animal evolution (i.e., cladograms and phylogenetic trees) and develop cladograms and phylogenetic trees.*

MAQ.6.3 *Develop a dichotomous classification key to be used in the identification of sample aquatic invertebrates.*

MAQ.6.4 *Compare and contrast major body plans (e.g., asymmetry, radial, bilateral symmetry, acoelomate, pseudocoelomate, and eucoelomate).*

MAQ.6.5 *Explain various life cycles found among animals (e.g., polyp and medusa in cnidarians, multiple hosts and stages in the platyhelminthic life cycle, and arthropod metamorphosis).*

MAQ.6.6 *Dissect representative taxa (e.g., clam and squid), collect data, compare their internal and external anatomy, analyze, explain, and communicate results.*

MAQ.6.7 *Using key morphological and physiological adaptations found within animal taxa, assess how animals interact with their environment to determine their ecological roles.*

MAQ.6.8 ***Enrichment:*** *Given a niche in a specific environment, use an engineering design process to design an animal, listing characteristics based on your knowledge of shared and derived characters, internal and external anatomy, and how the animal would adapt morphologically and physiologically relative to its ecological role and specific environment.**

Marine and Aquatic Science II

MAQ.7 Vertebrate Consumers

Conceptual Understanding: Other consumers that inhabit aquatic ecosystems are found within Phylum Chordata. While many of these consumers share basic morphological characteristics, derived characteristics demonstrate evolutionary relationships. Various adaptations are found among these organisms for successful niches within selected ecosystems.

MAQ.7 Students will investigate characteristics of aquatic invertebrates.

MAQ.7.1 *Characterize aquatic representatives of the following taxa: Hemichordata, Urochordata, Cephalochordata, and Vertebrata (including Agnatha, Chondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, and Mammalia).*

MAQ.7.2 *Identify characteristics that are shared and derived using graphical representation of animal evolution, and develop cladograms/phylogenetic trees.*

MAQ.7.3 *Utilize a dichotomous key to identify select aquatic vertebrates.*

MAQ.7.4 *Differentiate various life cycles found among animals (e.g., egg, tadpole, and adult stages of the amphibian life cycle; leathery eggs on land in reptiles; hard-shelled eggs in Aves; placental, marsupial, or monotremes in mammals; viviparous, ovoviviparous, and oviparous animals).*

MAQ.7.5 *Dissect representative taxa (e.g., shark, fish); collect data; compare their internal and external anatomy; and analyze, explain, and communicate results.*

MAQ.7.6 *Using key morphological and physiological adaptations found within aquatic vertebrate taxa, assess how animals interact with their environment to determine their ecological roles.*

MAQ.7.7 ***Enrichment:*** *Given a niche in a specific environment, use an engineering design process to design an animal, listing characteristics based on your knowledge of shared and derived characteristics, internal and external anatomy, and how the animal would adapt morphologically and physiologically relative to its ecological role and specific environment.**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

PHYSICAL SCIENCE

Physical Science, **a one-credit course,** provides opportunities for students to develop and communicate a basic understanding of physics and chemistry through lab-based activities, integrated STEM activities, inquiry, suitable mathematical expressions, and concept exploration. The Physical Science course will prepare students for the transition to other science courses and to become informed citizens of a modern world that is constantly changing. To be successful in Physical Science, it is recommended that students have completed Algebra I (Integrated Math I) or be enrolled in this math course.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should actively engage in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

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Physical Science

PHS.1 Nature of Matter

Conceptual Understanding: To actively develop scientific investigation, reasoning, and logic skills, this standard develops basic ideas about the characteristics and structure of matter. Matter is anything that has mass and occupies space. All matter is made up of small particles called atoms. Matter can exist as a solid, liquid, gas, or plasma.

PHS.1 Students will demonstrate an understanding of the nature of matter.

PHS.1.1 *Use contextual evidence to describe particle theory of matter. Examine the particle properties of solids, liquids, and gases.*

PHS.1.2 *Use scientific research to generate models to compare physical and chemical properties of elements, compounds, and mixtures.*

PHS.1.3 *Conduct an investigation to determine the identity of unknown substances by comparing properties to known substances.*

PHS.1.4 *Design and conduct investigations to explore techniques in measurements of mass, volume, length, and temperature.*

PHS.1.5 *Design and conduct an investigation using graphical analysis (e.g., line graph) to determine the density of liquids and/or solids.*

PHS.1.6 *Use mathematical and computational analysis to solve density problems. Manipulate the density formula to determine density, volume, or mass or use dimensional analysis to solve problems.*

Physical Science

PHS.2 Atomic Theory

Conceptual Understanding: Many scientists have contributed to our understanding of atomic structure. The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, electron, and quark) that differ in their location, charge, and relative mass.

PHS.2 **Students will demonstrate an understanding of both modern and historical theories of atomic structure.**

PHS.2.1 *Research and develop models (e.g., 3-D models, online simulations, or ball and stick) to investigate both modern and historical theories of atomic structure. Compare models and contributions of Dalton, Thomson, Rutherford, Bohr, and of modern atomic theory.*

Physical Science

PHS.3 Periodic Table

Conceptual Understanding: The organization of the periodic table allows scientists to obtain information and develop an understanding of concepts of atomic interactions. Developing scientific investigations increases logical reasoning and deduction skills to present the nature of science in the context of key scientific concepts.

PHS.3 **Students will analyze the organization of the periodic table of elements to predict atomic interactions.**

PHS.3.1 *Use contextual evidence to determine the organization of the periodic table, including metals, metalloids, and nonmetals; symbols; atomic number; atomic mass; chemical families/groups; and periods/series.*

PHS.3.2 *Using the periodic table and scientific methods, investigate the formation of compounds through ionic and covalent bonding.*

PHS.3.3 *Using naming conventions for binary compounds, write the compound name from the formula, and write balanced formulas from the name (e.g., carbon dioxide - CO_2, sodium chloride - NaCl, iron III oxide- Fe2O3, and calcium bromide - $CaBr_2$).*

PHS.3.4 *Use naming conventions to name common acids and common compounds used in classroom labs (e.g., sodium bicarbonate (baking soda), $NaHCO_3$; hydrochloric acid, HCl; sulfuric acid, H_2SO_4 ; acetic acid (vinegar), $HC_2H_3O_2$; and nitric acid, HNO_3).*

PHS.3.5 *Use mathematical and computational analysis to determine the atomic mass of binary compounds.*

Physical Science

PHS.4 The Law of Conservation of Matter and Energy

Conceptual Understanding: The law of conservation of matter and energy states that matter and energy can be transformed in different ways, but the total amount of mass and energy will be conserved. These concepts should be investigated and further developed in the classroom.

PHS.4 Students will analyze changes in matter and the relationship of these changes to the law of conservation of matter and energy.

PHS.4.1 *Design and conduct experiments to investigate physical and chemical changes of various household products (e.g., rusting, sour milk, crushing, grinding, tearing, boiling, and freezing) and reactions of common chemicals that produce color changes or gases.*

PHS.4.2 *Design and conduct investigations to produce evidence that mass is conserved in chemical reactions (e.g., vinegar and baking soda in a Ziploc© bag).*

PHS.4.3 *Apply the concept of conservation of matter to balancing simple chemical equations.*

PHS.4.4 *Use mathematical and computational analysis to examine evidence that mass is conserved in chemical reactions using simple stoichiometry problems (1:1 mole ratio) or atomic masses to demonstrate the conservation of mass with a balanced equation.*

PHS.4.5 *Research nuclear reactions and their uses in the modern world, exploring concepts such as fusion, fission, stars as reactors, nuclear energy, and chain reactions.*

PHS.4.6 *Analyze and debate the advantages and disadvantages of nuclear reactions as energy sources.*

Physical Science

PHS.5 Newton's Laws of Motion

Conceptual Understanding: Kinematics (contact forces) describe the motion of objects using words, diagrams, numbers, graphs, and equations. The goal of any study of kinematics is to develop scientific models to describe and explain the motion of real-world objects. Newton's laws of motion are an example of a tool that can aid in the explanation of motion.

PHS.5 Students will analyze the scientific principles of motion, force, and work.

PHS.5.1 *Research the scientific contributions of Newton, and use models to communicate Newton's principles.*

PHS.5.2 *Design and conduct an investigation to study the motion of an object using properties such as displacement, time of motion, velocity, and acceleration.*

PHS.5.3 *Collect, organize, and interpret graphical data using correct metric units to determine the average speed of an object.*

PHS.5.4 *Use mathematical and computational analyses to show the relationships among force, mass, and acceleration (i.e., Newton's second law).*

PHS.5.5 *Design and construct an investigation using probe systems and/or online simulations to observe relationships between force, mass, and acceleration (F=ma).*

PHS.5.6 *Use an engineering design process and mathematical analysis to design and construct models to demonstrate the law of conservation of momentum (e.g., roller coasters, bicycle helmets, bumper systems).*

PHS.5.7 *Use mathematical and computational representations to create graphs and formulas that describe the relationships between force, work, and energy (i.e., W=Fd, KE=½ mv^2, PE=mgh, W=KE).*

PHS.5.8 *Research the efficiency of everyday machines, and debate ways to improve their economic impact on society (e.g., electrical appliances, transportation vehicles).*

Physical Science

PHS.6 Waves

Conceptual Understanding: Waves are everywhere in nature. Understanding of the physical world is not complete until we understand the nature, properties, and behaviors of waves. Students have experienced transverse and horizontal waves in their everyday lives. The exploration of waves in greater depth will allow students to conceptualize these waves. The goal is to develop various models of waves and apply those models to understanding wave interactions.

PHS.6 Students will explore the characteristics of waves.

PHS.6.1 *Use models to analyze and describe examples of mechanical waves' properties (e.g., wavelength, frequency, speed, amplitude, rarefaction, and compression).*
PHS.6.2 *Analyze examples and evidence of transverse and longitudinal waves found in nature (e.g., earthquakes, ocean waves, and sound waves).*
PHS.6.3 *Generate wave models to explore energy transference.*
PHS.6.4 ***Enrichment:*** *Use an engineering design process to design and build a musical instrument to demonstrate the influence of resonance on music.**
PHS.6.5 *Design and conduct experiments to investigate technological applications of sound (e.g., medical uses, music, acoustics, Doppler effects, and influences of mathematical theory on music).*
PHS.6.6 *Research real-world applications to create models or visible representations of the electromagnetic spectrum, including visible light, infrared radiation, and ultraviolet radiation.*
PHS.6.7 ***Enrichment:*** *Use an engineering design process to design and construct an apparatus that forms images to project on a screen or magnify images using lenses and/or mirrors.**
PHS.6.8 ***Enrichment:*** *Debate the particle/wave behavior of light.*

Physical Science

PHS.7 Energy

Conceptual Understanding: Concepts about different energy forms and energy transformations continue to be expanded and explored in greater depth, leading to the development of more mathematical applications. Focus should be on students actively developing scientific investigations, reasoning, and logic skills.

PHS.7 Students will examine different forms of energy and energy transformations.

PHS.7.1 *Using digital resources, explore forms of energy (e.g., potential and kinetic energy, mechanical, chemical, electrical, thermal, radiant, and nuclear energy).*
PHS.7.2 *Use scientific investigations to explore the transformation of energy from one type to another (e.g., potential to kinetic energy, and mechanical, chemical, electrical, thermal, radiant, and nuclear energy interactions).*
PHS.7.3 *Using mathematical and computational analysis, calculate potential and kinetic energy based on given data. Use equations such as* $PE=mgh$ *and* $KE=\frac{1}{2} mv^2$.
PHS.7.4 *Conduct investigations to provide evidence of the conservation of energy as energy is converted from one form of energy to another (e.g., wind to electric, chemical to thermal, mechanical to thermal, and potential to kinetic).*

Physical Science

PHS.8 Thermal Energy

Conceptual Understanding: Thermal energy is transferred in the form of heat. Heat is always transferred from an area of high heat to low heat. More complex concepts and terminology related to phase changes are developed, including the distinction between heat and temperature.

PHS.8 Students will demonstrate an understanding of temperature scales, heat, and thermal energy transfer.

PHS.8.1 *Compare and contrast temperature scales by converting between Celsius, Fahrenheit, and Kelvin.*

PHS.8.2 *Apply particle theory to phase change and analyze freezing point, melting point, boiling point, vaporization, and condensation of different substances.*

PHS.8.3 *Relate thermal energy transfer to real world applications of conduction (e.g., quenching metals), convection (e.g., movement of air masses/weather/plate tectonics), and radiation (e.g., electromagnetic).*

PHS.8.4 ***Enrichment:*** *Use an engineering design process to construct a simulation of heat energy transfer between systems. Calculate the calories/joules of energy generated by burning food products. Communicate conclusions based on evidence from the simulation.**

Physical Science

PHS.9 Electricity

Conceptual Understanding: Electrical energy (both battery and circuit energy) is transformed into other forms of energy. Charged particles and magnetic fields are similar because they both store energy. Magnetic fields exert forces on moving charged particles. Students investigate practical uses of these concepts and develop a working understanding of the basic concepts of magnetism and electricity.

PHS.9 Students will explore basic principles of magnetism and electricity (e.g., static electricity, current electricity, and circuits).

PHS.9.1 *Use digital resources and online simulations to investigate the basic principles of electricity, including static electricity, current electricity, and circuits. Use digital resources (e.g., online simulations) to build a model showing the relationship between magnetic fields and electric currents.*

PHS.9.2 *Distinguish between magnets, motors, and generators, and evaluate modern industrial uses of each.*

PHS.9.3 ***Enrichment:*** *Use an engineering design process to construct a working electric motor to perform a task. Communicate the design process and comparisons of task performance efficiencies.**

PHS.9.4 *Use an engineering design process to construct and test conductors, semiconductors, and insulators using various materials to optimize efficiency.**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

PHYSICS

Physics, **a one-credit course,** provides opportunities for students to develop and communicate an understanding of matter and energy through lab-based activities, integrated STEM activities, mathematical expressions, and concept exploration. Concepts covered in this course include kinematics, dynamics, energy, mechanical and electromagnetic waves, and electricity. Laboratory activities, uses of technology, effective communication of results, and research of contemporary scientific theories through various methods are integral components of this course. Science as inquiry is an integral part of the framework, placing emphasis on developing the ability to ask questions, observe, experiment, measure, problem solve, gather data, and communicate findings. Inquiry is not an isolated unit of instruction and must be embedded throughout the content strands. All Physics laboratories need to be well equipped with the materials and apparatuses necessary to allow students to have meaningful experiences in the laboratory. To be successful in Physics, it is recommended that students have completed Algebra I. Geometry, and Algebra II (Integrated Math I, II, II), and be enrolled in an upper level math course.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world to increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a laboratory-based course, students are expected to utilize the science and engineering practices to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should actively engage in inquiry activities, laboratory experiences, and scientific research (projects) for a minimum of 30% of class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Physics

PHY.1 One-Dimensional Motion

Conceptual Understanding: Linear motion of objects is described by displacement, velocity, and acceleration. These concepts should be introduced as computational and investigative phenomena.

PHY.1 Students will investigate and understand how to analyze and interpret data.

PHY.1.1 *Investigate and analyze evidence gained through observation or experimental design regarding the one-dimensional (1-D) motion of objects. Design and conduct experiments to generate and interpret graphical evidence of distance, velocity, and acceleration through motion.*
PHY.1.2 *Interpret and predict 1-D motion based on displacement vs. time, velocity vs. time, or acceleration vs. time graphs (e.g., free-falling objects).*
PHY.1.3 *Use mathematical and computational analysis to solve problems using kinematic equations.*
PHY.1.4 *Use graphical analysis to derive kinematic equations.*

PHY.1.5	*Differentiate and give examples of motion concepts such as distance-displacement, speed-velocity, and acceleration.*
PHY.1.6	*Design and mathematically/graphically analyze quantitative data to explore displacement, velocity, and acceleration of various objects. Use probe systems, video analysis, graphical analysis software, digital spreadsheets, and/or online simulations.*
PHY.1.7	*Design different scenarios, and predict graph shapes for distance/time, velocity/time, and acceleration/time graphs.*
PHY.1.8	*Given a 1D motion graph students should replicate the motion predicted by the graph.*

Physics

PHY.2 Newton's Laws

Conceptual Understanding: Motion and acceleration can be explained by analyzing the contact interaction of objects. This motion and acceleration can be predicted by analyzing the forces (i.e., normal, tension, gravitational, applied, and frictional) acting on the object and applying Newton's laws of motion.

PHY.2 Students will develop an understanding of concepts related to Newtonian dynamics.

PHY.2.1	*Identify forces acting on a system by applying Newton's laws mathematically and graphically (e.g., vector and scalar quantities).*
PHY.2.2	*Use models such as free-body diagrams to explain and predict the motion of an object according to Newton's law of motion, including circular motion.*
PHY.2.3	*Use mathematical and graphical techniques to solve vector problems and find net forces acting on a body using free-body diagrams and/or online simulations.*
PHY.2.4	*Use vectors and mathematical analysis to explore the 2D motion of objects. (i.e. projectile and circular motion).*
PHY.2.5	*Use mathematical and computational analysis to derive simple equations of motion for various systems using Newton's second law (e.g. net force equations).*
PHY.2.6	*Use mathematical and computational analysis to explore forces (e.g., friction, force applied, normal, and tension).*
PHY.2.7	*Analyze real-world applications to draw conclusions about Newton's three laws of motion using online simulations, probe systems, and/or laboratory experiences.*
PHY.2.8	*Design an experiment to determine the forces acting on a stationary object on an inclined plane. Test your conclusions.*
PHY.2.9	*Draw diagrams of forces applied to an object, and predict the angle of incline that will result in unbalanced forces acting on the object.*
PHY.2.10	*Apply the effects of the universal gravitation law to generate a digital/physical graph, and interpret the forces between two masses, acceleration due to gravity, and planetary motion (e.g., situations where g is constant, as in falling bodies).*
PHY.2.11	*Explain centripetal acceleration while undergoing uniform circular motion to explore Kepler's third law using online simulations, models, and/or probe systems.*

Physics

PHY.3 Work and Energy

Conceptual Understanding: Work and energy are synonymous. When investigating mechanical energy, energy is the ability to do work. The rate at which work is done is called power. Efficiency is the ratio of power input to the output of the system. In closed systems, energy is conserved.

PHY.3 Students will develop an understanding of concepts related to work and energy.

PHY.3.1 *Use mathematical and computational analysis to qualitatively and quantitatively analyze the concept of work, energy, and power to explain and apply the conservation of energy.*
PHY.3.2 *Use mathematical and computational analysis to explore conservation of momentum and impulse.*
PHY.3.3 *Through real-world applications, draw conclusions about mechanical potential energy and kinetic energy using online simulations and/or laboratory experiences.*
PHY.3.4 *Design and conduct investigations to compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions using probe systems, online simulations, and/or laboratory experiences.*
PHY.3.5 *Investigate, collect data, and summarize the principles of thermodynamics by exploring how heat energy is transferred from higher temperature to lower temperature until equilibrium is reached.*
PHY.3.6 ***Enrichment****: Design, conduct, and communicate investigations that explore how temperature and thermal energy relate to molecular motion and states of matter.*
PHY.3.7 ***Enrichment:*** *Use mathematical and computational analysis to analyze problems involving specific heat and heat capacity.*
PHY.3.8 ***Enrichment:*** *Research to compare the first and second laws of thermodynamics as related to heat engines, refrigerators, and thermal efficiency.*
PHY.3.9 *Explore the kinetic theory in terms of kinetic energy of ideal gases using digital resources.*
PHY.3.10 ***Enrichment:*** *Research the efficiency of everyday machines (e.g., automobiles, hair dryers, refrigerators, and washing machines).*
PHY.3.11 ***Enrichment:*** *Use an engineering design process to design and build a themed Rube Goldberg-type machine that has six or more steps and complete a desired task (e.g., pop a balloon, fill a bottle, shoot a projectile, or raise an object 35 cm) within an allotted time. Include a poster that demonstrates the calculations of the energy transformation or efficiency of the machine.**

Physics

PHY.4 Waves

Conceptual Understanding: Wave properties are the transfer of energy from one place to another. The investigation of these interactions must include simple harmonic motion, sound, and electromagnetic radiation.

PHY.4 Students will investigate and explore wave properties.

PHY.4.1 *Analyze the characteristics and properties of simple harmonic motions, sound, and light.*
PHY.4.2 *Describe and model through digital or physical means the characteristics and properties of mechanical waves by simulating and investigating properties of simple harmonic motion.*
PHY.4.3 *Use mathematical and computational analysis to explore wave characteristics (e.g., velocity, period, frequency, amplitude, phase, and wavelength).*
PHY.4.4 *Investigate and communicate the relationship between the energy of a wave in terms of amplitude and frequency using probe systems, online simulations, and/or laboratory experiences.*
PHY.4.5 *Design, investigate, and collect data on standing waves and waves in specific media (e.g., stretched string, water surface, and air) using online simulations, probe systems, and/or laboratory experiences.*

PHY.4.6 *Explore and explain the Doppler effect as it relates to a moving source and to a moving observer using online simulations, probe systems, and/or real-world experiences.*

PHY.4.7 *Explain the laws of reflection and refraction, and apply Snell's law to describe the relationship between the angles of incidence and refraction.*

PHY.4.8 *Use ray diagrams and the thin lens equations to solve real-world problems involving object distance from lenses, using a lens bench, online simulations, and/or laboratory experiences.*

PHY.4.9 *Research the different bands of electromagnetic radiation, including characteristics, properties, and similarities/differences.*

PHY.4.10 ***Enrichment:*** *Research the ways absorption and emission spectra are used to study astronomy and the formation of the universe.*

PHY.4.11 ***Enrichment:*** *Research digital nonfictional text to defend the wave-particle duality of light (i.e., wave model of light and particle model of light).*

PHY.4.12 ***Enrichment:*** *Research uses of the electromagnetic spectrum or photoelectric effect.*

Physics

PHY.5 Electricity and Magnetism

Conceptual Understanding: In electrical interactions, electrical energy (whether battery or circuit energy) is transformed into other forms of energy. Charged particles and magnetic fields are similar in that they store energy. Magnetic fields exert forces on moving charged particles. Changing magnetic fields cause electrons in wires to move and thus create a current.

PHY.5 Students will investigate the key components of electricity and magnetism.

PHY.5.1 *Analyze and explain electricity and the relationship between electricity and magnetism.*

PHY.5.2 *Explore the characteristics of static charge and how a static charge is generated using simulations.*

PHY.5.3 *Use mathematical and computational analysis to analyze problems dealing with electric field, electric potential, current, voltage, and resistance as related to Ohm's law.*

PHY.5.4 *Develop and use models (e.g., circuit drawing and mathematical representation) to explain how electric circuits work by tracing the path of electrons, including concepts of energy transformation, transfer, conservation of energy, electric charge, and resistance using online simulations, probe systems, and/or laboratory experiences.*

PHY.5.5 *Design and conduct an investigation of magnetic poles, magnetic flux and magnetic field using online simulations, probe systems, and/or laboratory experiences.*

PHY.5.6 *Use schematic diagrams to analyze the current flow in series and parallel electric circuits, given the component resistances and the imposed electric potential.*

PHY.5.7 *Analyze and communicate the relationship between magnetic fields and electrical current by induction, generators, and electric motors (e.g., microphones, speakers, generators, and motors) using Ampere's and Faraday's laws.*

PHY.5.8 ***Enrichment:*** *Design and construct a simple motor to develop an explanation of how the motor transforms electrical energy into mechanical energy and work.*

PHY.5.9 ***Enrichment:*** *Design and draw a schematic of a circuit that will turn on/off a light from two locations in a room like those found in most homes.*

Physics

PHY.6 Nuclear Energy

Conceptual Understanding: Nuclear energy is energy stored in the nucleus of the atom. The energy holding atoms together is called binding energy. The binding energy is a huge amount of energy. So, at the subatomic scale, the conservation of energy becomes the conservation of mass-energy.

PHY.6 Students will demonstrate an understanding of the basic principles of nuclear energy.

PHY.6.1 *Analyze and explain the concepts of nuclear physics.*
PHY.6.2 *Explore the mass number and atomic number of the nucleus of an isotope of a given chemical element.*
PHY.6.3 *Investigate the conservation of mass and the conservation of charge by writing and balancing nuclear decay equations for alpha and beta decay.*
PHY.6.4 *Simulate the process of nuclear decay using online simulations and/or laboratory experiences and using mathematical computations determine the half-life of radioactive isotopes.*

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.

ZOOLOGY I (Invertebrate)
ZOOLOGY II (Vertebrate)

Zoology I, **a one-half credit course**, and Zoology II, **a one-half credit course**, are laboratory-based courses that survey the nine major phyla of the Kingdom Animalia. Morphology, taxonomy, anatomy, and physiology are investigated. Comparative studies are addressed during laboratory observations and dissections. Laboratory activities, research, the use of technology, and the effective communication of results through various methods are integral components of this course. It is recommended that Zoology I and/or Zoology II be taken after the successful completion of Biology.
NOTE: Students do **not** have to complete Zoology I before enrolling in Zoology II. The disciplinary core idea ZOO.1, Evolution, does not have to be repeated in Zoology II if students have successfully completed Zoology I and are continuing study with Zoology II.

The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world that increase the depth of understanding based on evidence, logic, and innovation. These concepts are expected to appear throughout the course. As a lab-based course, students are expected to design and conduct investigations using appropriate equipment, measurement (SI units), and safety procedures. Students should also design data tables and draw conclusions using mathematical computations and/or graphical analysis. It is recommended that students should be actively engaged in inquiry activities, lab experiences, and scientific research (projects) for a minimum of 30% of the class time.

The standards and performance objectives do not have to be taught in the order presented in this document. The performance objectives are intentionally broad to allow school districts and teachers the flexibility to create a curriculum that meets the needs of their students.

Objectives identified by "**Enrichment:**" are considered enrichment material that may be expanded upon as time permits. Engineering standards are represented in some performance objectives with specific wording that will prompt students to approach learning and exploration using the engineering process. **These performance objectives are marked with an * at the end of the statement.**

Zoology I

ZOO.1 Evolution

Conceptual Understanding: Evolution results from the interaction of four factors: (1) the potential for a species to increase in number, (2) genetic variation occurring within a species due to mutations and sexual reproduction, (3) limited supply of resources needed for survival resulting in competition, and (4) those organisms that are better adapted for an environment survive and reproduce. Genetic information provides evidence of evolution. DNA sequences vary among species, but some similarities remain. By comparing the DNA sequences of different organisms, multiple lines of descent may be inferred. The ongoing branching into multiple lines of descent may also be derived by comparing the amino acid sequences and by examining the anatomical and embryological evidence.

ZOO.1 Students will develop a model of evolutionary change over time.

ZOO.1.1 *Develop and use dichotomous keys to distinguish animals from protists, plants, and fungi.*
ZOO.1.2 *Describe how the fossil record documents the history of life on earth.*
ZOO.1.3 *Recognize that the classification of living organisms is based on their evolutionary history and/or similarities in fossils and living organisms.*

ZOO.1.4 *Construct cladograms or phylogenetic trees to show the evolutionary branches of an ancestral species and its descendants.*

ZOO.1.5 *Design models to illustrate the interaction between changing environments and genetic variation in natural selection leading to adaptations in populations and differential success of populations.*

ZOO.1.6 ***Enrichment:*** *Use an engineering design process to develop an artificial habitat to meet the requirements of a population that has been impacted by human activity.**

Zoology I

ZOO.2 Phyla Porifera and Cnidaria

Conceptual Understanding: Phyla Porifera and Cnidaria are two of the most primitive of animal phyla. They distinguish themselves from other metazoans by their lack of bilateral symmetry. Each phylum has its own anatomy, physiology, and unique role in aquatic ecosystems.

ZOO.2 Students will understand the structure and function of phylum Porifera and phylum Cnidaria and how each adapts to their environments.

ZOO.2.1 *Differentiate among asymmetry, radial symmetry, and bilateral symmetry in an animal's body plan.*

ZOO.2.2 *Identify the anatomy and physiology of a sponge, including how specialized cells within sponges work cooperatively without forming tissues to capture and digest food.*

ZOO.2.3 *Describe the importance of phylum Porifera in aquatic habitats.*

ZOO.2.4 *Create a model, either physical or digital, illustrating the anatomy of a sponge, tracing the flow of water.*

ZOO.2.5 ***Enrichment:*** *Use an engineering design process to determine the quantity of water that may be absorbed per unit in a natural sponge versus a synthetic sponge.**

ZOO.2.6 *Contrast the polyp lifestyle of most Cnidarians with the medusa lifestyle of jellyfish, including how both utilize a single body opening.*

ZOO.2.7 *Describe how nematocysts (stinging cells) of Cnidarians are used for capturing food and for defense.*

ZOO.2.8 ***Enrichment:*** *Utilize an engineering design process to create a simulated nematocyst, including possible biomimicry use.**

ZOO.2.9 *Describe the ecological importance of and human impacts on coral reefs.*

ZOO.2.10 *Create a digital or physical model illustrating the anatomy of a cnidarian, citing similarities and differences between polyps and medusas.*

Zoology I

ZOO.3 Phylum Mollusca

Conceptual Understanding: Phylum Mollusca is one of the most diverse phyla on earth, occupying almost every type of ecosystem. Despite its diversity, mollusks share a basic body plan and are well adapted to their niches within environments.

ZOO.3 Students will understand the structure and function of phylum Mollusca, and how they adapt to their environments.

ZOO.3.1 *Considering the diversity of mollusks, explain how they all share a common body plan (i.e., mantle, visceral mass, and foot).*

ZOO.3.2 *Describe why mollusks are classified as eucoelomates.*
ZOO.3.3 *Explain how the mantle is used in forming the shell.*
ZOO.3.4 *Describe how the radula is used in feeding.*
ZOO.3.5 *Develop a dichotomous key to contrast characteristics of gastropods, bivalves, and cephalopods.*
ZOO.3.6 *Examine how the unique characteristics of cephalopods lead to survival.*
ZOO.3.7 *Create a model comparing the anatomy of gastropods, bivalves, and cephalopods.*
ZOO.3.8 ***Enrichment:*** *Use an engineering design process to model the jet propulsion utilized by cephalopods in mechanical design of fluid systems (e.g., improving hydraulic systems).**

Zoology I

ZOO.4 Phyla Platyhelminthes, Nematoda, and Annelida

Conceptual Understanding: Although the term "worms" may refer to an organism with a long, slender, soft body with bilateral symmetry, worms may be subdivided into phyla based on their unique body plan. These include phyla Platyhelminthes, Nematoda, and Annelida.

ZOO.4 Students will describe the evolution of structure and function of phylum Platyhelminthes, phylum Nematoda, and phylum Annelida.

ZOO.4.1 *Define and describe the closed circulatory system of an annelid.*
ZOO.4.2 *Differentiate between parasitic and free living.*
ZOO.4.3 *Compare and contrast the characteristics and lifestyles of flatworms, roundworms, and segmented worms.*
ZOO.4.4 *Create a model comparing acoelomate, pseudocoelomate, and eucoelomate body plans of Platyhelminthes, Nematoda, and Annelida.*
ZOO.4.5 *Describe the evolutionary importance of the segmented body plans of annelids.*
ZOO.4.6 *Dissect representative taxa, and compare their internal and external anatomy and complexity.*
ZOO.4.7 ***Enrichment:*** *Design, conduct, and communicate results of an experiment demonstrating the importance of flatworms, roundworms, and annelids for human use (e.g., the earthworm in agriculture and the leech in medicine).*
ZOO.4.8 ***Enrichment:*** *Use an engineering design process to design and construct a system to utilize flatworms, roundworms, or annelids to meet a human need.**

Zoology I

ZOO.5 Phylum Arthropoda

Conceptual Understanding: Arthropods are the most successful of animal phyla, inhabiting land, sea, and air. Despite their differences, all arthropods share some characteristics enabling them to be united as one phylum.

ZOO.5 Students will understand the basic structure and function of phylum Arthropoda, and how they demonstrate the characteristics of living things.

ZOO.5.1 *Describe the evolutionary advantages of segmented bodies, hard exoskeletons, and jointed appendages to arthropods and how they contribute to arthropods being the largest phyla in species diversity and the most geographically diverse.*
ZOO.5.2 *Explain how the exoskeleton is used in locomotion, protection, and development.*

ZOO.5.3 ***Enrichment:*** *Use an engineering design process to develop a biomimicry of an arthropod's exoskeleton to meet a human need.**
ZOO.5.4 *Identify organisms and characteristics of chelicerates, crustaceans, and insects.*
ZOO.5.5 *Describe the importance of toxins for arachnids, such as spiders and scorpions.*
ZOO.5.6 *Describe the importance of chela for decapods, such as lobsters and crabs.*
ZOO.5.7 *Differentiate between complete and incomplete metamorphosis in insects' life cycles.*
ZOO.5.8 *Explain the importance of eusociality in insects, such as ants, bees, and termites.*
ZOO.5.9 *Dissect representative taxa, and compare their internal and external anatomy and complexity.*

Zoology I

ZOO.6 Phylum Echinodermata

Conceptual Understanding: Phylum Echinodermata contains complex organisms exhibiting pentaradial symmetry and a sophisticated water vascular system.

ZOO.6 Students will understand the structure and function of phylum Echinodermata, and how they demonstrate the characteristics of living things.

ZOO.6.1 *Recognize that the echinoderms have spines on their skin that are extensions of plates that form from the endoskeleton.*
ZOO.6.2 *Explain how the starfish inverts its stomach for external digestion of food.*
ZOO.6.2 *Describe sea urchins' and sea cucumbers' defense structures and behaviors.*
ZOO.6.3 *Describe the sexual and asexual reproduction of starfish.*
ZOO.6.4 *Describe how the water vascular system is used for locomotion, feeding, and gas exchange.*
ZOO.6.5 *Research, analyze, and communicate implications of applying the regeneration of starfish to human medicine.*
ZOO.6.6 *Dissect representative taxa and compare their internal and external anatomy and complexity.*
ZOO.6.7 ***Enrichment:*** *Use an engineering design process to model the water vascular system in hydraulic systems to meet a societal need.**

Zoology II

ZOO.1 Evolution *

*** This standard does not have to be repeated if students have taken Zoology I during the first term.**

Conceptual Understanding: Evolution results from the interaction of four factors: (1) the potential for a species to increase in number, (2) genetic variation occurring within a species due to mutations and sexual reproduction, (3) limited supply of resources needed for survival resulting in competition, and (4) those organisms that are better adapted for an environment survive and reproduce. Genetic information provides evidence of evolution. DNA sequences vary among species, but some similarities remain. By comparing the DNA sequences of different organisms, multiple lines of descent may be inferred. The ongoing branching into multiple lines of descent may also be derived by comparing the amino acid sequences and by examining the anatomical and embryological evidence.

ZOO.1 Students will develop a model of evolutionary change over time.

ZOO.1.1 *Develop and use dichotomous keys to distinguish animals from protists, plants, and fungi.*
ZOO.1.2 *Describe how the fossil record documents the history of life on earth.*
ZOO.1.3 *Recognize that the classification of living organisms is based on their evolutionary history and/or similarities in fossils and living organisms.*

ZOO.1.4 *Construct cladograms or phylogenetic trees to show the evolutionary branches of an ancestral species and its descendants.*

ZOO.1.5 *Design models to illustrate the interaction between changing environments and genetic variation in natural selection leading to adaptations in populations and differential success of populations.*

ZOO.1.6 ***Enrichment:*** *Use an engineering design process to develop an artificial habitat to meet the requirements of a population that has been impacted by human activity.**

Zoology II

ZOO.7 Phylum Chordata, Classes Chondrichthyes and Osteichthyes

Conceptual Understanding: Of the members of phylum Chordata, fish species are most numerous. These aquatic vertebrates have gills throughout their lives and either have or are descended from ancestors with scales or armor.

ZOO.7 Students will understand the structure and function of phylum Chordata, classes Chondrichthyes and Osteichthyes, and how they demonstrate the characteristics of living things.

ZOO.7.1 *Students will understand why evolutionary changes lead to the diversity of fish and how they have adapted to the different aquatic environments.*

ZOO.7.2 *Compare and contrast the characteristics of class Chondrichthyes and Osteichthyes.*

ZOO.7.3 *Identify specific fish species and characteristics that differentiate class Chondrichthyes (e.g., sharks, skates, and rays).*

ZOO.7.4 *Describe how the body and jaw design of sharks make them adept predators.*

ZOO.7.5 *Label and describe functions of the anatomical features of the bony fish, including internal organs, lateral line system, operculum, swim bladder, and external fins.*

ZOO.7.6 *Research, analyze, and communicate the effects of urbanization and continued expansion by humans on the biodiversity of fish species (e.g., overfishing and invasive species).*

ZOO.7.7 *Dissect representative taxa and compare their internal and external anatomy and complexity.*

ZOO.7.8 ***Enrichment:*** *Use an engineering design process to design a "balloon fish" that has neutral buoyancy (i.e., does not sink or float). Report which materials were used to create the "fish," and predict which materials should be added to make the "fish" sink and which materials would make the "fish" float.**

Zoology II

ZOO.8 Phylum Chordata, Classes Amphibia and Reptilia

Conceptual understanding: The two groups of ectothermic tetrapods—amphibians and reptiles—are similar in appearance, but differ drastically in development and body structure.

ZOO.8 Students will understand the structure and function of phylum Chordata, classes Amphibia and Reptilia, and how they demonstrate the characteristics of living things.

ZOO.8.1 *Understand the evolution of tetrapods and the development of the structure and function of body systems and life cycles.*

ZOO.8.2 *Describe the constraints that require amphibians to spend part of their lives in water and part on land, including the morphological and physiological changes as they pass from one stage of their life cycle to the next.*

ZOO.8.3 *Describe adaptations that have led to reptiles living on land successfully.*

ZOO.8.4 *Define what it means to be ectothermic, and identify ways in which reptiles regulate their body temperature.*

ZOO.8.5 *Describe how snakes use chemosensory to locate and track prey.*

ZOO.8.6 ***Enrichment:*** *Use an engineering design process to model biomimicry of ectothermic temperature regulation or chemosensory detection to meet a societal need.**

ZOO.8.7 *Compare and contrast living and extinct reptiles.*

ZOO.8.8 *Explain the importance of tetrapod evolution.*

ZOO.8.9 *Identify the amniotic egg as the major derived characteristic of reptiles.*

ZOO.8.10 *Dissect representative taxa and compare their internal and external anatomy and complexity.*

Zoology II

ZOO.9 Phylum Chordata, Class Aves

Conceptual understanding: Class Aves, including birds, are endothermic, egg-laying vertebrates with bodies covered in feathers. Although they are descendants of dinosaurs, they have evolved a unique physiology, making most capable of flight.

ZOO.9 Students will understand the structure and function of phylum Chordata, class Aves, and how they demonstrate the characteristics of living things.

ZOO. 9.1 *Trace the evolutionary history of modern birds beginning with the theropods. Relate how today's birds have adapted to changing environments.*

ZOO. 9.2 *Describe the fossil evidence that indicates that birds evolved from two-legged dinosaurs called theropods.*

ZOO. 9.3 *Define the term endothermic, and describe how birds regulate body temperature in extreme environments.*

ZOO. 9.4 ***Enrichment:*** *Use an engineering design process to model biomimicry of endothermic temperature regulation to meet a sustainable need.**

ZOO. 9.5 *Explain how birds of prey use their keen sense of sight to locate and attack prey.*

ZOO. 9.6 *Describe how corvids use their intellect for problem solving and locating food storage.*

ZOO. 9.7 *Explain the importance of the evolution of flight and feathers, including the morphological and physiological adaptations needed to sustain flight.*

ZOO. 9.8 ***Enrichment:*** *Use an engineering design process to utilize a bird's flight adaptations in the development of a flying aircraft (e.g., glider, plane).**

ZOO. 9.9 *Demonstrate how different adaptations of the bird beak and feet allow them to feed and survive in different environments.*

ZOO. 9.10 ***Enrichment:*** *Based on an understanding of biomimicry, use an engineering design process to develop a tool based on a bird's beak/feet to meet a human need. **

ZOO. 9.11 *Describe the parenting behavior of different birds in order to incubate their eggs and care for hatchlings.*

ZOO. 9.12 ***Enrichment:*** *Use an engineering design process to design and construct an incubator for hatching abandoned eggs.**

ZOO. 9.13 *Explain the reasons for bird migration and the innate behavior of migratory birds.*

ZOO. 9.14 *Dissect representative taxa and compare their internal and external anatomy and complexity.*

Zoology II

ZOO.10 Phylum Chordata, Class Mammalia

Conceptual Understanding: Class Mammalia consists of endothermic organisms with hair, a four-chambered heart, a diaphragm, and mammary glands. As inhabitants of every continent, they are successful in a great variety of ecosystems.

ZOO.10 Students will understand the structure and function of phylum Chordata, class Mammalia, and how they demonstrate the characteristics of living things.

ZOO 10.1 *Understand the characteristics and behaviors that distinguish mammals from other phyla, and use characteristics and behaviors to distinguish the major orders, including primates. Explain how human impact has changed the environments of other organisms.*

ZOO 10.2 *Describe the characteristics of the first true mammal.*

ZOO 10.3 *Distinguish among monotremes, marsupials, and eutherians, and describe the importance and differences in the placenta in marsupials and eutherians.*

ZOO 10.4 *Describe characteristics that make primates unique, including investigating how the center of gravity relates to the evolution of bipedalism.*

ZOO 10.5 *Dissect representative taxa and compare their internal and external anatomy and complexity.*

ZOO 10.6 *Explain how human impacts have changed the environment of aquatic and terrestrial organisms (e.g., habitat destruction, urbanization, and climate change).*

ZOO 10.7 ***Enrichment:*** *Use an engineering design process to develop a possible solution to an environmental issue that currently exists in an ecosystem.**

Overarching (start to finish) SEPs for Inquiry Extension of Labs

Ask questions to generate hypotheses for scientific investigations based on empirical evidence and observations and/or ask questions to **clarify or refine** models, explanations, or designs.

Plan and conduct controlled scientific investigations to produce data to answer questions, test hypotheses and predictions, and develop explanations or evaluate design solutions, which require the following:

- Identify dependent and independent variables and appropriate controls.
- Select and use appropriate tools or instruments to collect data, and represent data in an appropriate form.
- Analyze and interpret various types of data sets, using appropriate mathematics, in order to verify or refute the hypothesis or determine an optimal design solution.
- Construct an explanation of observed relationships between variables.
- Communicate scientific and/or technical information in various formats.