ARKANSAS

K-12 SCIENCE STANDARDS

EDUCATION FOR A NEW GENERATION

Human Anatomy and Physiology

2016

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Notes:

1. Student Performance Expectations (PEs) may be taught in any sequence or grouping within a grade level. Several PEs are described as being “partially addressed in this course” because the same PE is revisited in a subsequent course during which that PE is fully addressed.
2. An asterisk (*) indicates an engineering connection to a practice, core idea, or crosscutting concept.
3. The performance expectation codes ending in AR indicate Arkansas-specific standards.
4. The clarification statements are examples and additional guidance for the instructor.
5. The assessment boundaries delineate content that may be taught but not assessed in large-scale assessments.
6. The section entitled “foundation boxes” is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Integrated and reprinted with permission from the National Academy of Sciences.
7. The examples given (e.g.,) are suggestions for the instructor.
8. Throughout this document, connections are provided to the nature of science as defined by *A Framework for K-12 Science Education* (NRC 2012).
9. Throughout this document, connections are provided to Engineering, Technology, and Applications of Science as defined by *A Framework for K-12 Science Education* (NRC 2012).
10. Each set of PEs lists connections to other disciplinary core ideas (DCIs) within the Arkansas K-12 Science Standards and to the Arkansas English Language Arts Standards, Arkansas Disciplinary Literacy Standards, and the Arkansas Mathematics Standards.

Arkansas K-12 Science Standards Overview

The Arkansas K-12 Science Standards are based on *A Framework for K-12 Science Education* (NRC 2012) and are meant to reflect a new vision for science education. The following conceptual shifts reflect what is new about these science standards. The Arkansas K-12 Science Standards

- reflect science as it is practiced and experienced in the real world,
- build logically from Kindergarten through Grade 12,
- focus on deeper understanding as well as application of content,
- integrate practices, crosscutting concepts, and core ideas, and
- make explicit connections to literacy and math.

As part of teaching the Arkansas K-12 Science Standards, it will be important to instruct and guide students in adopting appropriate safety precautions for their student-directed science investigations. Reducing risk and preventing accidents in science classrooms begin with planning. The following four steps are recommended in carrying out a hazard and risk assessment for any planned lab investigation:

1) Identify all hazards. Hazards may be physical, chemical, health, or environmental.
2) Evaluate the type of risk associated with each hazard.
3) Write the procedure and all necessary safety precautions in such a way as to eliminate or reduce the risk associated with each hazard.
4) Prepare for any emergency that might arise in spite of all of the required safety precautions.

According to Arkansas Code Annotated § 6-10-113 (2012) for eye protection, every student and teacher in public schools participating in any chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids is required to wear industrial-quality eye protective devices (eye goggles) at all times while participating in science investigations.

The Arkansas K-12 Science Standards outline the knowledge and science and engineering practices that all students should learn by the end of high school. The standards are three-dimensional because each student performance expectation engages students at the nexus of the following three dimensions:

- Dimension 1 describes scientific and engineering practices.
- Dimension 2 describes crosscutting concepts, overarching science concepts that apply across science disciplines.
- Dimension 3 describes core ideas in the science disciplines.

Science and Engineering Practices

The eight practices describe what scientists use to investigate and build models and theories of the world around them or that engineers use as they build and design systems. The practices are essential for all students to learn and are as follows:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

8. Obtaining, evaluating, and communicating information

Crosscutting Concepts

The seven crosscutting concepts bridge disciplinary boundaries and unit core ideas throughout the fields of science and engineering. Their purpose is to help students deepen their understanding of the disciplinary core ideas, and develop a coherent, and scientifically based view of the world. The seven crosscutting concepts are as follows:

1. *Patterns*- Observed patterns of forms and events guide organization and classification, and prompt questions about relationships and the factors that influence them.
2. *Cause and effect- Mechanism and explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
3. *Scale, proportion, and quantity*- In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and system models*- Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and matter: Flows, cycles, and conservation*- Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and function*- The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.
7. *Stability and change*- For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Disciplinary Core Ideas

The disciplinary core ideas describe the content that occurs at each grade or course. The Arkansas K-12 Science Standards focus on a limited number of core ideas in science and engineering both within and across the disciplines and are built on the notion of learning as a developmental progression. The Disciplinary Core Ideas are grouped into the following domains:

- Physical Science (PS)
- Life Science (LS)
- Earth and Space Science (ESS)
- Engineering, Technology and Applications of Science (ETS)

Connections to the Arkansas English Language Arts Standards

Evidence-based reasoning is the foundation of good scientific practice. The Arkansas K-12 Science Standards incorporate reasoning skills used in language arts to help students improve mastery and understanding in all three disciplines. The Arkansas K-8 Science Committee made every effort to align grade-by-grade with the English language arts (ELA) standards so concepts support what students are learning in their entire curriculum. Connections to specific ELA standards are listed for each student performance expectation, giving teachers a blueprint for building comprehensive cross-disciplinary lessons.

The intersections between Arkansas K-12 Science Standards and Arkansas ELA Standards teach students to analyze data, model concepts, and strategically use tools through productive talk and shared activity. Reading in science requires an appreciation of the norms and conventions of the discipline of science, including understanding

the nature of evidence used, an attention to precision and detail, and the capacity to make and assess intricate arguments, synthesize complex information, and follow detailed procedures and accounts of events and concepts. These practice-based standards help teachers foster a classroom culture where students think and reason together, connecting around the subject matter and core ideas.

Connections to the Arkansas Disciplinary Literacy Standards

Reading is critical to building knowledge in science. College and career ready reading in science requires an appreciation of the norms and conventions of each discipline, such as the kinds of evidence used in science; an understanding of domain-specific words and phrases; an attention to precise details; and the capacity to evaluate intricate arguments, synthesize complex information, and follow detailed descriptions of events and concepts. When reading scientific and technical texts, students need to be able to gain knowledge from challenging texts that often make extensive use of elaborate diagrams and data to convey information and illustrate concepts. Students must be able to read complex informational texts in science with independence and confidence because the vast majority of reading in college and workforce training programs will be sophisticated nonfiction.

For students, writing is a key means of asserting and defending claims, showing what they know about science, and conveying what they have experienced, imagined, thought, and felt. To be college and career ready writers, students must take task, purpose, and audience into careful consideration, choosing words, information, structures, and formats deliberately. They need to be able to use technology strategically when creating, refining, and collaborating on writing. They have to become adept at gathering information, evaluating sources, and citing material accurately, reporting finds from their research and analysis of sources in a clear and cogent manner. They must have the flexibility, concentration, and fluency to produce high-quality first-draft text under a tight deadline and the capacity to revisit and make improvements to a piece of writing over multiple drafts when circumstances encourage or require it.

Connections to the Arkansas Mathematics Standards

Science is a quantitative discipline, so it is important for educators to ensure that students' science learning coheres well with their understanding of mathematics. To achieve this alignment, the Arkansas K-12 Science Committee made every effort to ensure that the mathematics standards do not outpace or misalign to the grade-by-grade science standards. Connections to specific math standards are listed for each student performance expectation, giving teachers a blueprint for building comprehensive cross-disciplinary lessons.

How to Read
Arkansas K-12 Science

Topic

GRADE TWO

An asterisk indicates an engineering connection to a practice or disciplinary core idea.

Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

2-LS2-1 **Plan and conduct an investigation to determine if plants need sunlight and water to grow.** [Assessment Boundary: Assessment is limited to testing one variab

2-LS2-2 **Develop a simple model that mimics the function o** **eeds or pollinating plants.** *

2-LS4-1 **Make observations of plants and animals to compa** **fferent habitats.** [Clarification Statement: Emphasis is on the diversity of living thing in a variety of habitats.] [Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.]

Student Performance Expectations (PEs)

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.

- Develop a simple model based on evidence to represent a proposed object or too (2-LS2-2)

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.

- Plan and conduct an investig collaboratively to produce da as the basis for evidence to question. (2-LS2-1)
- Make observations (firsthand or from media) to collect data that can be used to make comparisons. (2-LS4-1)

Designates which PE uses this practice

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Scientists look for patterns and order when making observations about the world. (2-LS4-1)

Connections to the Nature of Science

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Plants depend on water and light to grow. (2-LS2-1)
- Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)

LS4.D: Biodiversity and Humans

- There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)

ETS1.B: Developing Possible Solutions

- Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (2-LS2-2)
-

Designates which PE incorporates this disciplinary core idea (DCI)

Crosscutting Concepts

Cause and Effect

- Events have causes that generate observable patterns. (2-LS2-1)

Structure and Function

- The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)

Designates which PE incorporates this crosscutting concept (CC)

Connections to other DCIs in second grade: N/A

Connections to other DCIs across grade levels: **K.LS1.C** (2-LS2-1); **K-ESS3.A** (2-LS2-1); **K-2.ETS1.A** (2-LS2-2); **3.LS4.C** (2-LS4-1); **3.LS4.D** (2-LS4-1); **5.LS1.C** (2-LS2-1); **5.LS2.A** (2-LS2-2, 2-LS4-1)

DCI codes from *A Framework for K-12 Science Education* in boldface type.

Connections to the Arkansas English Language Arts and Mathematics Standards are often found by scrolling to the next page

Human Anatomy and Physiology Course Learning Progression Chart

Topic 1: Patterns	HAP-LS1-1AR
Topic 2: Structure and Function	HAP-LS2-1AR
Topic 3: Scale, Proportion, and Quantity	HAP-LS3-1AR
Topic 4: Stability and Change	HAP-LS4-1AR
Topic 5: Cause and Effect	HAP-LS5-1AR
Topic 6: Energy and Matter	HAP-LS6-1AR
Topic 7: Systems and System Models	HAP-LS7-1AR
Topic 8: Career Exploration with Engineering Practices	HAP-8-1AR HAP-8-2AR HAP-8-3AR

Arkansas Performance Expectations (AR)

Human Anatomy and Physiology Course Overview

(Course code 424030)

The Arkansas K-12 Science Standards for human anatomy and physiology is a science course that continues to develop conceptual understanding of the core ideas, science and engineering practices, and crosscutting concepts in biology - integrated. Teachers with a biology, life/Earth, life science license (including 611 and 625 technical permits) or others as approved by ADE are able to teach this course. Students will earn 1 Core requirement/career focus credit.

The Arkansas K-12 Science Standards course on human anatomy and physiology is a curriculum framework of high school student performance expectations based on the core ideas of the life sciences (LS) and crosscutting concepts in *A Framework for K-12 Science Education* (NRC 2012). This is a career-focused course for students interested in medical professions and related fields. The performance expectations build logically from the high school biology - integrated course.

The performance expectations clarify what students need to know and be able to do at the end of the course. Student performance expectations consist of three dimensions: science and engineering practices, disciplinary core ideas, and crosscutting concepts. Engineering practices are meant to be integrated into science instruction to support the learning of science phenomena at all levels from Kindergarten to Grade 12.

The structure of the human anatomy and physiology course is guided by the crosscutting concepts identified in the *Framework* that bridge disciplinary boundaries, uniting core ideas throughout the fields of science and engineering. The purpose is to help students understand the disciplinary core ideas and develop a coherent and scientifically based view of the world. Students in human anatomy and physiology develop understanding of key concepts that help them make sense of the interactions among the eleven human body systems. These include:

- Integumentary System
- Skeletal System
- Muscular System
- Respiratory System
- Circulatory System
- Digestive System
- Nervous System
- Endocrine System
- Lymphatic System
- Urinary System
- Reproductive System

Additionally, it should be noted that the human anatomy and physiology standards are not intended to be used as curriculum. Instead, the standards are the minimum that students should know and be able to do. Therefore, teachers should continue to differentiate for the needs of their students by adding depth and additional rigor.

Human Anatomy and Physiology Topics Overview

Students in human anatomy and physiology develop understanding of key concepts that help them make sense of the interactions among systems within the human body. The ideas build upon student understanding of the disciplinary core ideas, science and engineering practices, and crosscutting concepts from earlier grades. There are eight topics in human anatomy and physiology: (1) Patterns, (2) Structure and Function, (3) Scale, Proportion, and Quantity, (4) Stability and Change, (5) Cause and Effect, (6) Energy and Matter, (7) Systems and System Models, and (8) Career Exploration with Engineering Practices. While the performance expectations indicate particular practices to address specific disciplinary core ideas, it is recommended that teachers include a variety of practices and strategies in their instruction.

The performance expectations in **Topic 1: Patterns** help students answer the question:

- How is the body organized?

Students construct explanations based on evidence obtained from a variety of sources for the pattern of hierarchical organization of each body system. Explanations could include student investigations, models, simulations, and scientific texts.

The performance expectations in **Topic 2: Structure and Function** help students answer the question:

- How do the structures that comprise each system enable the human body to function?

Students develop and use models to identify and describe the structures and physiological processes of each body system. Emphasis is on organs and their component tissues.

The performance expectations in **Topic 3**: **Scale, Proportion, and Quantity** help students answer the question:

- How can data be used to support explanations of body functions?

Students use mathematical and/or computational representations to support explanations of body system function(s). Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors that could include blood pressure, body mass index, surface area, ratios, etc. Examples of mathematical comparisons could include graphs, charts, or histograms formulated from data sets.

The performance expectations in **Topic 4: Stability and Change** help students answer the question:

- How is homeostasis maintained in a dynamic environment?

Students plan and conduct investigations to provide evidence that feedback mechanisms maintain homeostasis. Investigations may relate to heart rate, temperature, blood sugar, and hormone levels.

The performance expectations in **Topic 5: Cause and Effect** help students answer the question:

- How can genetic and environmental factors disrupt functions of the body?

Students make and defend claims based on evidence to examine the relationship between dysfunction(s) in each body system and the mechanism by which it is caused. Emphasis is on using data to support arguments on topics such as disease, disorder, or injury.

The performance expectations in **Topic 6: Energy and Matter** help students answer the question:

- How do energy and matter flow throughout the human body?

Students construct and revise explanations based on evidence for the cycling of matter and flow of energy among body systems and their associated processes. Examples could include respiration, digestion, absorption, circulation, and filtration.

The performance expectations in **Topic 7: System and System Models** help students answer the question:

- How does the interaction between body systems contribute to the function of the human body?

Students develop and use models to illustrate the interactions of systems that control or affect specific functions within the human body. Emphasis is on functions at the body system level such as nutrient uptake, water delivery, and movement in response to neural stimuli.

The performance expectations in **Topic 8: Career Exploration with Engineering Practices** help students answer the question:

- How can students prepare for current and emerging careers related to human health?
- How can engineering practices address real-world challenges related to human health?

Students obtain, evaluate, and communicate information related to health science professions. Students design a solution to a complex real-world problem affecting body systems that can be solved through engineering. Students evaluate solutions to a complex real-world human health problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Human Anatomy and Physiology

Topic 1: Patterns

Students who demonstrate understanding can:

HAP-LS1-1AR **Construct an explanation based on evidence obtained from a variety of sources for the pattern of hierarchical organization of each body system:**

- **Integumentary System**
- **Skeletal System**
- **Muscular System**
- **Respiratory System**
- **Circulatory System**
- **Digestive System**
- **Nervous System**
- **Endocrine System**
- **Lymphatic System**
- **Urinary System**
- **Reproductive Systems**

[Clarification Statement: Evidence for explanations could be gathered from student investigations, models, simulations, and scientific texts.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HAP-LS1-1AR)
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HAP-LS1-1AR)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories,

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. ()
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS1-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS1-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS1-1AR)

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HAP-LS1-1AR)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

  (HAP-LS1-1AR)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make

simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HAP-LS1-1AR) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HAP-LS1-1AR)		claims about specific causes and effects. (HAP-LS1-1AR) **Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HAP-LS1-1AR)

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS1-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HAP-LS1-1AR)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HAP-LS1-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS1-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS1-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS1-1AR)

MP.4 Model with mathematics. (HAP-LS1-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS1-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS1-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS1-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS1-1AR)

Topic 2: Structure and Function

Students who demonstrate understanding can:

HAP-LS2-1AR Develop and use a model to identify and describe the relationship between the structures and physiological processes of each body system:

- **Integumentary System**
- **Skeletal System**
- **Muscular System**
- **Respiratory System**
- **Circulatory System**
- **Digestive System**
- **Nervous System**
- **Endocrine System**
- **Lymphatic System**
- **Urinary System**
- **Reproductive Systems**

[Clarification Statement: Emphasis is on the structure and function relationships between organs and the component tissues of each system.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HAP-LS2-1AR)

Planning and Carrying Out Investigations

Planning and carrying out in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HAP-LS2-1AR)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS2-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS2-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS2-1AR)

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HAP-LS2-1AR)

Structure and Function

- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HAP-LS2-1AR)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS2-1AR)

of trials, cost, risk, time), and refine the design accordingly. (HAP-LS2-1AR) **Asking Questions and Defining Problems** Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. ▪ Ask questions that arise from examining models or a theory to clarify relationships. (HAP-LS2-1AR) ---------- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. (HAP-LS2-1AR)	**LS1.B: Growth and Development of Organisms** In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HAP-LS2-1AR) **LS1.C: Organization for Matter and Energy Flow in Organisms** ▪ The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HAP-LS2-1AR) ▪ The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HAP-LS2-1AR) ▪ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HAP-LS2-1AR)	**Patterns** ▪ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HAP-LS2-1AR) **Stability and Change** ▪ Feedback (negative or positive) can stabilize or destabilize a system. (HAP-LS2-1AR) **Energy and Matter** ▪ Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HAP-LS2-1AR) ▪ Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HAP-LS2-1AR) ▪ The total amount of energy and matter in closed systems is conserved. (HAP-LS2-1AR) ▪ Energy drives the cycling of matter within and between systems. (HAP-LS2-1AR)

	▪ As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HAP-LS2-1AR) **LS1.D: Information Processing** ▪ Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (HAP-LS2-1AR)	

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS2-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. (HAP-LS2-1AR)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HAP-LS2-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS2-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS2-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS2-1AR)

MP.4 Model with mathematics. (HAP-LS2-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS2-1AR)

HSS.ID.A.1 Represent data with plots on the real number line. (HAP-LS2-1AR)

HSS.ID.B.6 Represent data on two quantitative variables on a scatterplot, and describe how the variables are related: fit a function to the data; use functions fitted to data to solve problems in the context of data; informally assess the fit of a function by plotting and analyzing residuals. (HAP-LS2-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS2-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS2-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS2-1AR)

Human Anatomy and Physiology

Topic 3: Scale, Proportion, and Quantity

Students who demonstrate understanding can:

HAP-LS3-1AR **Use mathematics and computational thinking to support explanations for physiological processes in body systems.** [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors that could include blood pressure, body mass index, surface area ratios. Examples of mathematical models could include graphs, charts, or histograms.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Using Mathematics and Computational Thinking
Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical and/or computational representations of phenomena or design solutions to support explanations. (HAP-LS3-1AR)
- Use mathematical representations of phenomena or design solutions to support and revise explanations. (HAP-LS3-1AR)
- Create or revise a simulation of a phenomenon, designed device, process, or system. (HAP-LS3-1AR)
- Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HAP-LS3-1AR)

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using,

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HAP-LS3-1AR)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS3-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS3-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS3-1AR)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS3-1AR)

Scale, Proportion, and Quantity

- The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HAP-LS3-1AR)
- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HAP-LS3-1AR)

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HAP-LS3-1AR)

synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ▪ Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HAP-LS3-1AR) **Analyzing and Interpreting Data** Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ▪ Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HAP-LS3-1AR) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. ▪ Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HAP-LS3-1AR) ---------- ***Connections to Nature of Science*** **Scientific Knowledge is Open to Revision in Light of New Evidence** ▪ Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. (HAP-LS3-1AR)	of tissues and organs that work together to meet the needs of the whole organism. (HAP-LS3-1AR) **LS1.C: Organization for Matter and Energy Flow in Organisms** ▪ The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HAP-LS3-1AR) The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HAP-LS3-1AR) ▪ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HAP-LS3-1AR) ▪ As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HAP-LS3-1AR) **LS1.D: Information Processing** ▪ Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (HAP-LS3-1AR)	

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS3-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HAP-LS3-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS3-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS3-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS3-1AR)

MP.4 Model with mathematics. (HAP-LS3-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS3-1AR)

HSS.IC.B.3 Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to sample surveys, experiments, and observational studies. (HAP-LS3-1AR)

HSS.IC.B.5 Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant. (HAP-LS3-1AR)

HSS.ID.A.1 Represent data with plots on the real number line. (HAP-LS3-1AR)

HSS.ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how the variables are related: fit a function to the data; use functions fitted to data to solve problems in the context of the data; informally assess the fit of a function by plotting and analyzing residuals. (HAP-LS3-1AR)

HSS.ID.C.8 Compute and interpret the correlation coefficient in a linear fit. (HAP-LS3-1AR)

HSS.ID.C.9 Distinguish between correlation and causation. (HAP-LS3-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS3-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS3-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS3-1AR)

Topic 4: Stability and Change

Students who demonstrate understanding can:

HAP-LS4-1AR Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of factors to investigate could include heart rate, temperature, blood sugar, and hormone levels.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Ask questions that arise from examining models or a theory to clarify relationships. (HAP-LS4-1AR)

Analyzing and Interpreting Data
Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HAP-LS4-1AR)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Make and defend a claim based on evidence about the natural world that reflects scientific knowledge, and student-generated evidence. (HAP-LS4-1AR)

Planning and Carrying Out Investigations
Planning and carrying out in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Disciplinary Core Ideas

LS1.A: Structure and Function

- All cells contain genetic information in Systems of specialized cells within organisms help them perform the essential functions of life. (HAP-LS4-1AR)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS4-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS4-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS4-1AR)

LS3.A: Inheritance of Traits

- Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different

Crosscutting Concepts

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HAP-LS4-1AR)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS4-1AR)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HAP-LS4-1AR)

Connections to Nature of Science

Science is a Human Endeavor

- Technological advances have influenced the progress of science and science has influenced advances in technology. (HAP-LS4-1AR)
- Science and engineering are influenced by society and society is influenced by science and engineering. (HAP-LS4-1AR)

▪ Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HAP-LS4-1AR)	ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HAP-LS4-1AR)	

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HAP-LS4-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS4-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS4-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS4-1AR)

MP.4 Model with mathematics. (HAP-LS4-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS4-1AR)

HSS.ID.C.8 Compute and interpret the correlation coefficient in a linear fit. (HAP-LS4-1AR)

HSS.ID.C.9 Distinguish between correlation and causation. (HAP-LS4-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS4-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS4-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS4-1AR)

Topic 5: Cause and Effect

Students who demonstrate understanding can:

HAP-LS5-1AR Argue from evidence the cause(s) for a dysfunction in a body system and the mechanisms by which it occurred. [Clarification Statement: Emphasis is on using data to support arguments for cause and effect relationships (e.g., diseases, disorders including genetic, and injuries).]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HAP-LS5-1AR)

Engaging in Argument from Evidence
Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.

- Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HAP-LS5-1AR)
- Construct an oral and written argument or counter-arguments based on data and evidence.

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HAP-LS5-1AR)
- All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS5-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS5-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS5-1AR)

LS1.B: Growth and Development of Organisms

- In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HAP-LS5-1AR)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS5-1AR)

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HAP-LS5-1AR)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HAP-LS5-1AR)

(including orally, graphically, textually, and mathematically). (HAP-LS5-1AR) ---------- ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ▪ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HAP-LS5-1AR)	together to meet the needs of the whole organism. (HAP-LS5-1AR) **LS1.D: Information Processing** ▪ Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (HAP-LS5-1AR) **LS4.A: Evidence of Common Ancestry and Diversity** ▪ Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence. (HAP-LS5-1AR) **LS4.C: Adaptation** ▪ Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HAP-LS5-1AR) ▪ Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HAP-LS5-1AR)	

	▪ Adaptation also means that the distribution of traits in a population can change when conditions change. (HAP-LS5-1AR)	

Connections to the Arkansas Disciplinary Literacy Standards:

WHST.9-12.1 Write arguments focused on discipline-specific content. (HAP-LS5-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS5-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS5-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS5-1AR)

MP.4 Model with mathematics. (HAP-LS5-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS5-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS5-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS5-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS5-1AR)

Topic 6: Energy and Matter

Students who demonstrate understanding can:

HAP-LS6-1AR **Construct and revise an explanation based on evidence for the cycling of matter and flow of energy among body systems and their associated processes.**
[Clarification Statement: Examples of processes could include respiration, digestion, absorption, circulation, and filtration.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to provide mechanistic accounts of phenomena. (HAP-LS6-1AR)

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HAP-LS6-1AR)
- Analyze data using computational models in order to make valid and reliable scientific claims. (HAP-LS6-1AR)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (HAP-LS6-1AR)
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HAP-LS6-1AR)
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HAP-LS6-1AR)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS6-1AR)

Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system. (HAP-LS6-1AR)
  Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HAP-LS6-1AR)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HAP-LS6-1AR)
- Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HAP-LS6-1AR)
- The total amount of energy and matter in closed systems is conserved. (HAP-LS6-1AR)

theories. ▪ Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HAP-LS6-1AR) ▪ Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HAP-LS6-1AR) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. ▪ Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HAP-LS6-1AR) ---------- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** ▪ Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HAP-LS6-1AR) ▪ New technologies advance scientific knowledge. (HAP-LS6-1AR) **Scientific Knowledge is Based on Empirical Evidence** ▪ Science knowledge is based on empirical evidence. (HAP-LS6-1AR) ▪ Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HAP-LS6-1AR)		▪ Energy drives the cycling of matter within and between systems. (HAP-LS6-1AR)

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS6-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HAP-LS6-1AR)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HAP-LS6-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS6-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS6-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS6-1AR)

MP.4 Model with mathematics. (HAP-LS6-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS6-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS6-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS6-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS6-1AR)

Topic 7: Systems and System Models

Students who demonstrate understanding can:

HAP-LS7-1AR Develop and use a model to illustrate the interactions between systems that control or affect specific functions within the human body. [Clarification Statement: Emphasis is on functions at the body system level such as nutrient uptake, water delivery, and movement in response to neural stimuli. An example of interaction between systems in nutrient uptake and absorption involves interactions between the digestive, circulation, and nervous systems.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HAP-LS7-1AR)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HAP-LS7-1AR)

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to provide mechanistic accounts of phenomena. (HAP-LS7-1AR)

Disciplinary Core Ideas

LS1.A: Structure and Function

- Systems of specialized cells within organisms help them perform the essential functions of life. (HAP-LS7-1AR)
  All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HAP-LS7-1AR)
- Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HAP-LS7-1AR)
- Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HAP-LS7-1AR)

LS1.D: Information Processing

- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (HAP-LS7-1AR)

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HAP-LS7-1AR)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HAP-LS7-1AR)
- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HAP-LS7-1AR)

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HAP-LS7-1AR)
- Energy cannot be created or destroyed—it only moves between one place and another place,

Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ▪ Create a computational model or simulation of a phenomenon, designed device, process, or system. (HAP-LS7-1AR) ▪ Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HAP-LS7-1AR) ▪ Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HAP-LS7-1AR)		between objects and/or fields, or between systems. (HAP-LS7-1AR) ▪ The total amount of energy and matter in closed systems is conserved. (HAP-LS7-1AR) ▪ Energy drives the cycling of matter within and between systems. (HAP-LS7-1AR) **Structure and Function** ▪ Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HAP-LS7-1AR) ---------- ***Connections to Nature of Science*** **Science is a Human Endeavor** ▪ Science is a result of human endeavors, imagination, and creativity. (HAP-LS7-1AR) **Science Addresses Questions About the Natural and Material World** ▪ Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HAP-LS7-1AR) ▪ Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human

		decisions about the use of knowledge. (HAP-LS7-1AR) ▪ Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HAP-LS7-1AR)

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS7-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HAP-LS7-1AR)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HAP-LS7-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS7-1AR)

Connections to the Arkansas Mathematics Standards:

MP.2 Reason abstractly and quantitatively. (HAP-LS7-1AR)

MP.4 Model with mathematics. (HAP-LS7-1AR)

MP.5 Use appropriate tools strategically. (HAP-LS7-1AR)

HSN.Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HAP-LS7-1AR)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HAP-LS7-1AR)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS7-1AR)

Topic 8: Career Exploration with Engineering Practices

Students who demonstrate understanding can:

HAP-8-1AR **Obtain, evaluate, and communicate information related to health science professions.** [Clarification Statement: Professions could include researcher, engineer, medical professional, technician, manufacturer and distributor, administrator, and data storage and security professional.]

HAP-8-2AR **Design a solution to a complex real-world problem affecting body systems that can be solved through engineering. *** [Clarification Statement: Solutions could include prosthetics, mobility enhancement, engineered body parts, treatment processes, and disease control.]

HAP-8-3AR **Evaluate a solution to a complex real-world human health problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. *** [Clarification Statement: Solutions could include the effects on the human body.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HAP-8-2AR, HAP-8-3AR)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HAP-8-2AR, HAP-8-3AR)

Asking Questions and Defining Problems

Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HAP-8-2AR, HAP-8-3AR)
- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HAP-8-2AR, HAP-8-3AR)

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HAP-8-2AR, HAP-8-3AR)
- Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making

Connections to Nature of Science

Science is a Human Endeavor

- Science is a result of human endeavors, imagination, and creativity. (HAP-8-1AR)

Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HAP-8-1AR)
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HAP-8-1AR)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HAP-8-1AR)

▪ Analyze complex real-world problems by specifying criteria and constraints for successful solutions (HAP-8-2AR, HAP-8-3AR) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. ▪ Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HAP-8-1AR)	a persuasive presentation to a client about how a given design will meet his or her needs. (HAP-8-2AR, HAP-8-3AR)	

Connections to the Arkansas Disciplinary Literacy Standards:

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HAP-LS8-1AR)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HAP-LS8-1AR)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HAP-LS8-1AR)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HAP-LS8-1AR)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HAP-LS8-1AR)

Connections to the Arkansas English Language Arts Standards:

SL.11-12.4 Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks. (HAP-LS8-1AR)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, auditory, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HAP-LS8-1AR)

Connections to the Arkansas Mathematics Standards:

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HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HAP-LS8-1AR)

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