IOWA | Department of Education

IOWA ACADEMIC STANDARDS FOR

Science

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Contents

Introduction

Our world is increasingly complex, making scientific and technological reasoning more essential than ever. In Iowa, it's clear that science, technology, and engineering play a vital role in the lives of all citizens. Whether analyzing current events, making informed healthcare decisions, or supporting the development of community infrastructure, a solid understanding of science is crucial. By the end of 12th grade, every student should appreciate the wonders of science and have the knowledge necessary to engage in meaningful discussions about scientific and technological issues that affect society. They must become discerning consumers of scientific and technological information and products in their daily lives.

Students' science experiences should inspire and equip them for the reality that most careers require some level of scientific or technical expertise. This education is not just for those pursuing STEM fields; it's essential for all students, regardless of their future education or career paths. Every Iowa student deserves an engaging, relevant, rigorous, and coherent pre-K–12 science education that prepares them for active citizenship, lifelong learning, and successful careers.

The Iowa's Academic Standards for Science were revised by Iowa educators and scientists, using a wide array of resources and expertise. A great deal is known about good science instruction. The writing team used over a dozen other state standards as references, consulted decades of science education research, and referenced local, national, and international sources including *The Framework for K-12 Science Education* (National Research Council, 2012), the *National Assessment of Educational Progress* (NAEP), examined Fordham's critique of science standards, and the Next Generation Science Standards (NGSS Lead States, 2013). The Iowa Academic Standards for Science were written by Iowa educators with students in mind, including developmentally appropriate progressions that foster learning that is simultaneously age-appropriate and enduring. Great care was taken to make the science standards relevant to Iowa's students including connections to Iowa phenomena, industries, and careers. The ultimate aim was to address what an educated citizen should know and understand to embrace the value of scientific thinking and make informed decisions. The Iowa Academic Standards for Science are founded on what science is, how science is learned, and the multiple dimensions of scientific work.

Student Active Sensemaking of Relevant Phenomena

Sensemaking empowers students to draw upon their prior knowledge, lived experiences, and prior conceptions related to scientific concepts. Educators leverage this approach to honor students' existing understandings and enrich classroom discussions with authenticity. Rather than simply correcting prior conceptions, teachers guide students through activities that help them explore and apply current scientific ideas. This process proves to be more effective for long-term knowledge retention, supports diverse student backgrounds, and promotes engagement with science and engineering practices (Cannady, 2019).

A phenomenon is an observable event that can serve to motivate and sustain student inquiry. Thoughtfully selected phenomena make science relevant by connecting it to students' everyday lives. A phenomenon that effectively motivates student inquiry is observable, intriguing, relevant, complex, and aligned with applicable educational standards. Engaging, authentic problems and phenomena foster intrinsic motivation for learning, enabling students to take ownership of their education. Research underscores that student motivation and engagement are essential in science and engineering education; they are not merely desirable but necessary for reaching all learners. The National Academies report, *Learning Through Citizen Science: Enhancing Opportunities by Design*, highlights that engaged students are more likely to embrace challenges, learn effectively, and utilize feedback constructively. Furthermore, the report outlines strategies to enhance student motivation, including: (1) offering choice and autonomy in learning, (2) fostering personal relevance, (3) presenting appropriately challenging material, and when appropriate (4) situating investigations within socially and culturally relevant contexts. Grounding instruction in phenomena and problems that resonate with students enhances all four of these strategies (National Academy of Sciences, 2018).

Ultimately, sensemaking is the journey students undertake to comprehend their world. This process involves accessing prior knowledge, generating initial ideas, gathering evidence, explaining or modeling concepts, and reaching consensus within the classroom. Through this collaborative endeavor, students develop new frameworks that aid in understanding future phenomena they encounter.

Three Dimensions in Science Standards

The Iowa Academic Standards for Science outline the standards for students, detailing what they should understand and be able to do through their science education. These standards are informed by the *Framework for K–12 Science Education* (National Academies, 2012) developed by the National Research Council. This framework identifies three key dimensions that together provide a high-quality science education. In Iowa, these dimensions are referred to as science practices, disciplinary core ideas, and crosscutting concepts. By integrating these dimensions, students gain context for scientific content, make sense of how scientific knowledge is acquired, and see the connections between different scientific concepts across disciplines.

Science and engineering practices (SEPs) empower students to engage in the processes of scientific inquiry and engineering design, fostering critical thinking and problem-solving skills that are crucial in today’s complex world. By actively participating in these practices, students not only learn scientific concepts but also develop a deeper understanding of how science works in real-world contexts, making the learning process more relevant and applicable to their lives. Science literacy empowers individuals to make informed decisions about their health, environment, and technology, improving personal well-being and societal engagement. It fosters critical thinking and problem-solving skills, enabling communities to address complex challenges like public health and technological advancements.

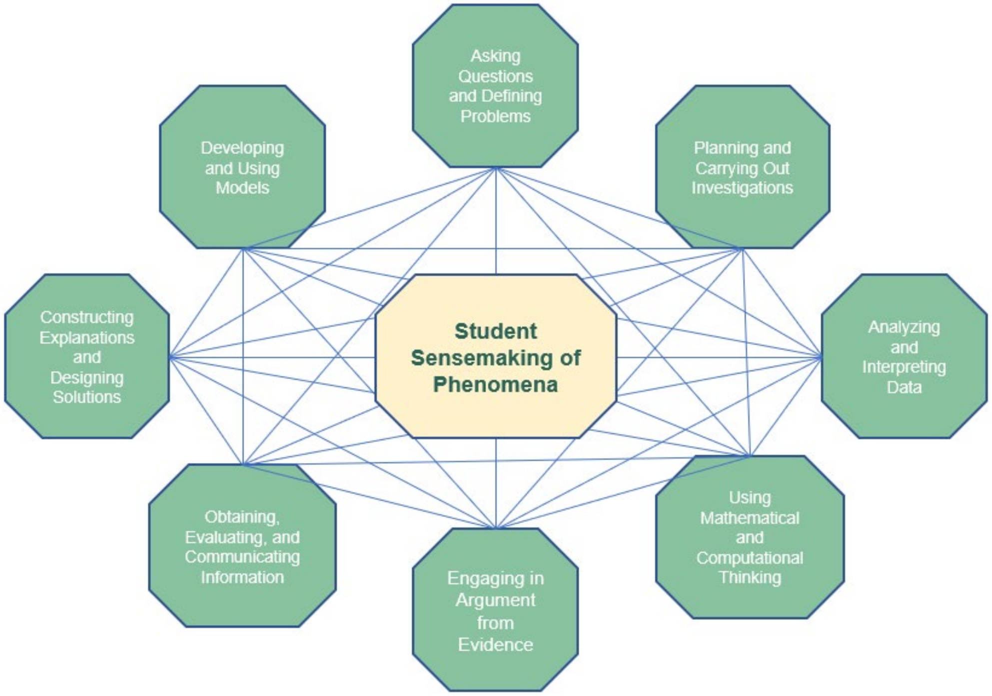
The integration of these dimensions allows students to connect knowledge across different scientific disciplines, promoting a holistic understanding of the natural world. Disciplinary core ideas (DCIs) focus on the fundamental concepts within each science area, while crosscutting concepts (CCCs) highlight universal themes that link various disciplines, such as cause and effect or systems thinking. This interconnected approach encourages students to think critically about scientific phenomena, see the relationships between different ideas, and apply their learning across various contexts. Ultimately, these three dimensions work together to prepare students for future scientific endeavors, lifelong learning, and informed citizenship in an increasingly scientific and technological society.

Science and Engineering Practices

Core practices employed by scientists and engineers in their investigations and designs require not just skills but also specialized knowledge. Scientific practices aim to clarify the concept of inquiry in science, specifying the cognitive, social, and physical elements involved. Students are expected to actively engage in these practices, rather than merely learn about them, allowing them to fully grasp the nature of scientific inquiry. Students should not engage with a single dimension in a lesson, but integrate dimensions throughout the lesson.

These practices mirror the work of scientists and engineers and are designed to enhance students’ skills while deepening their understanding of science and engineering. The following diagram outlines a list of the practices as well as how they can be used to make sense of the world. Note that scientists move from one practice to another in no specific order and are constantly engaging with these in order to make sense of scientific phenomena.

Science and Engineering Practices



The Iowa Academic Standards for Science outline specific endpoints for these practices across at each grade level, ensuring a progression of learning from early childhood through high school. Instruction should not focus solely on teaching practices in isolation. Instead, it should integrate these science and engineering practices within the context of learning, allowing students to apply disciplinary content knowledge actively as they make sense of relevant phenomena. This approach fosters deeper understanding and encourages students to engage meaningfully with the material.

At the high school level, the science and engineering practice clarification listed in the standard is set at the rigor for the end of a student's high school experience. If this standard is taught at an earlier grade level, expectations should be scaffolded so that by the end of the grade band, students have reached that level of expertise. Appendix A has been developed to aid in this scaffolding. For instance, if the standard is being taught at the freshman level, adjusting the practice to the “beginning” level on the Appendix A table would be appropriate.

Disciplinary Core Ideas

Given the vast and ever-expanding nature of scientific knowledge, it’s impractical to cover every concept in depth during K-12 education. Instead, science education in Iowa focuses on essential core ideas that equip students with the foundational knowledge necessary for future learning.

Disciplinary core ideas within the Iowa Academic Standards for Science include those most fundamental and explanatory pieces of knowledge in a discipline. They are often what we traditionally associate with science knowledge and specific subject areas within science. These core ideas are organized within physical, life, and earth sciences, but within each area further specific organization is appropriate. This approach encourages students to seek out additional information independently as needed.

Life Science

- LS1: From Molecules to Organisms: Structures and Processes
- LS2: Ecosystems, Interactions, Energy, and Dynamics
- LS3: Heredity, Inheritance and Variation of Traits
- LS4: Biological Evolution: Unity and Diversity

Physical Science

- PS1: Matter and Its Interactions
- PS2: Motion and Stability: Forces and Interactions
- PS3: Energy
- PS4: Waves and their Applications in Technology for Information Transfer

Earth and Space Science

- ESS1: Earth's Place in the Universe
- ESS2: Earth's Systems
- ESS3: Earth and Human Activity

Engineering, Technology & Society

- ETS1: Engineering Design
- ETS2: Links Among Engineering, Technology, Science and Society

Each core idea is structured as a developmental progression, enabling students to build and refine their knowledge from their initial curiosity about the world. The aim is to guide them toward a scientifically coherent understanding of natural sciences and engineering, as well as the methods used to pursue these fields. Instruction should not treat disciplinary core ideas as separate from crosscutting concepts or science and engineering practices. Instead, the content should provide a meaningful context for students to engage in scientific practices, allowing them to build cognitive frameworks that help them integrate new information with their existing knowledge. This interconnected approach fosters deeper understanding and promotes more effective learning.

Many standards include standard boundary statements within the disciplinary core idea clarifications, which define the depth and breadth of content for assessment purposes. These boundaries, along with the clarification statements, are designed to guide teachers in understanding the expected rigor for assessments. However, they are not intended to restrict the scope or approach to how science content is taught in the classroom.

Crosscutting Concepts

Crosscutting concepts are a set of conceptual tools that scientists and engineers use to reason about phenomena. These lenses are used across all science and engineering disciplines, and provide students with a framework to organize their understanding of the world and link core ideas across disciplines. One can understand crosscutting concepts by thinking of them as a frame (or lenses) through which a scientist sees the world. For example, much of science revolves around recognizing patterns in nature, whether it is how planets move around our sun, how elements can be arranged by properties on the periodic table, or how inheritance patterns connect to genetic diversity within a population. Recognizing that each of these examples involves analyzing patterns in nature can be a powerful tool in developing a student's perception of the world. By utilizing crosscutting concepts, students can make meaningful connections across subjects and apply scientific principles in a wide range of contexts.

- **Patterns**
- **Cause and Effect: Mechanism and Explanation**
- **Scale, Proportion and Quantity**
- **Systems and System Models**
- **Energy and matter: Flows, Cycles and Conservation**
- **Structure and Function**
- **Stability and Change**

The Iowa Academic Standards for Science define specific endpoints for these concepts at each grade level, facilitating a coherent learning experience across grades. At the high school level, the crosscutting concept clarification listed in the standard is set at the rigor for the end of a student's high school experience. If this standard is taught at an earlier grade level, expectations should be scaffolded so that by the end of the grade band, students have reached that level of expertise. Appendix B has been developed to aid in this scaffolding. For instance, if the standard is being taught at the freshman level, adjusting the crosscutting concept to the "beginning" level on the Appendix B table would be appropriate.

Scope and Sequence

All standards are designed to be accessible to all students. **The Iowa Academic Standards for Science are required for every student in grades kindergarten through high school.** This foundational commitment, emphasized in Iowa Academic Standards for Science, is crucial for unit and course design. It challenges commonly held misconceptions, for example that physics concepts are only for advanced math students or that earth and space sciences are only for those not on a college track. The principle remains clear: *all standards for all students*.

The three dimensions of science instruction are carefully sequenced through intentional learning progressions from kindergarten to high school. In each grade, both science and engineering practices and crosscutting concepts are consistently reinforced, allowing teachers the flexibility to revisit and deepen student understanding as needed. The expectations are structured so that key scientific ideas, practices and concepts are revisited at each grade band, building on prior learning. A student may first encounter a scientific principle in the K-2 band, expand on it in grades 3-5, revisit it in middle school, and finally master it in high school. This progression assumes that students have mastered prior expectations before progressing to more advanced content, practices, and crosscutting concepts. Omitting any dimension at any grade level disrupts this continuity and hinders the student's ability to meet new expectations, placing greater burdens on teachers in subsequent years. Sample progressions for each dimension are provided below:

Dimension	K-2 Band	3-5 Band	Middle School Band	High School Band
Science and Engineering Practice	Identify arguments that are supported by evidence.	Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
Disciplinary Core Idea	A bigger push or pull makes things go faster.	When objects collide, the contact forces transfer energy so as to change the objects' motions.	When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	When two objects interacting through a field change relative position, the energy stored in the field is changed.
Crosscutting Concept	Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.	Macroscopic patterns are related to the nature of microscopic and atomic-level structure.	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.

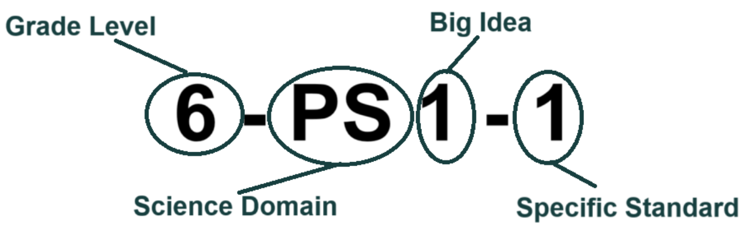
Standard boundaries, as outlined in some clarification statements, serve to indicate limits on proficiency expected for all students at each grade level. However, it's important to recognize that these standards represent floors, not ceilings. While boundaries may be specified, teachers should feel empowered to push students beyond these expectations when appropriate. It is the teacher's responsibility to assess each student's abilities and provide opportunities for them to reach their fullest potential, tailoring instruction to meet the needs of both individual students and the class as a whole.

Organization and Structure of the Standards

The Iowa Academic Standards for Science are organized by grade level for grades K-8 and by grade span in high school. K-5 standards are organized to reflect the developmental nature of learning for elementary students and attend to the learning progressions that build foundational understandings of science. By the time students reach middle school (Grades 6-8), they build on this foundation in order to develop more sophisticated understandings of science concepts through high school.

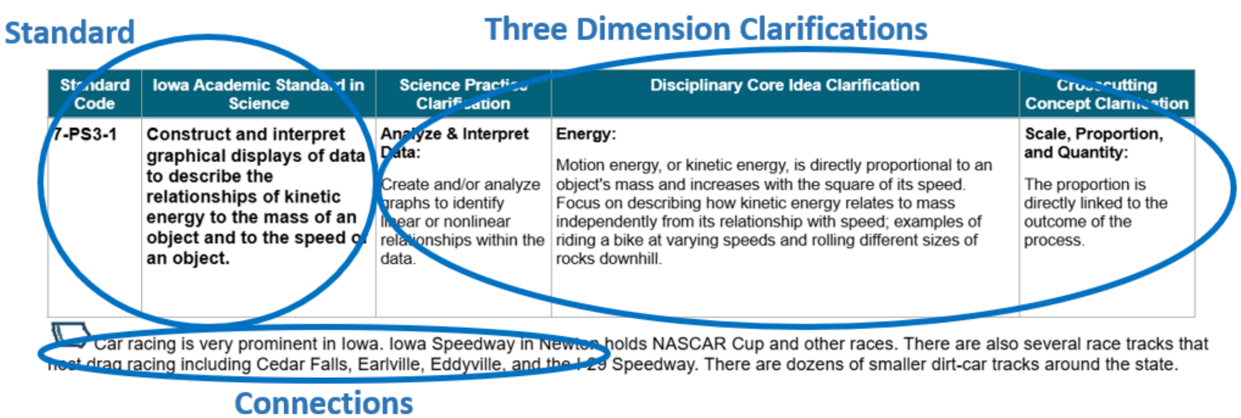
The Iowa Academic Standards for Science are designated with the following coding system.

- **Grade Level:** The standards are grade-specific in grades kindergarten through eighth grade. High school standards will be designated with HS.
- **Science Domain:** The standards are broken into the domains of life science (LS), physical science (PS), earth/space science (ESS), and engineering and technical sciences (ETS).
- **Big Idea:** Each science domain has several big ideas that make up the content within that domain. A list of the big ideas encased in each domain is above in the description of the disciplinary content dimension.



- **Specific Standard:** The big ideas are finally broken into three-dimensional specific standards that outline what students should know and be able to do when engaging with these standards. These standards each contain a scientific and engineering practice, crosscutting concept, and disciplinary core idea that should be referenced when planning three-dimensional instruction.

Each three-dimensional standard consists of three parts, the **standard**, and **clarifications of associated dimensions**, and identified **connections**. The standard identifies what performance expectation students are to meet. This includes disciplinary core ideas, science and engineering practices, and crosscutting concepts. The Grade Level Practice Clarification section provides additional information about the specific science practice(s) students should engage with. The disciplinary core idea clarification section provides clarity on the specific content to be addressed, provides example phenomena that students may engage with, and standard boundaries that serve as guidance for assessment. The crosscutting concept section offers additional information on the overarching conceptual frame that students should engage with to make broader connections among science.



Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS3-1	**Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.**	**Analyze & Interpret Data:** Create and/or analyze graphs to identify linear or nonlinear relationships within the data.	**Energy:** Motion energy, or kinetic energy, is directly proportional to an object's mass and increases with the square of its speed. Focus on describing how kinetic energy relates to mass independently from its relationship with speed; examples of riding a bike at varying speeds and rolling different sizes of rocks downhill.	**Scale, Proportion, and Quantity:** The proportion is directly linked to the outcome of the process.

Car racing is very prominent in Iowa. Iowa Speedway in Newton holds NASCAR Cup and other races. There are also several race tracks that host drag racing including Cedar Falls, Earlville, Eddyville, and the I-29 Speedway. There are dozens of smaller dirt-car tracks around the state.

Connections

Many standards include possible connections that teachers can leverage when planning their instruction. The identified connections are not required in the way that the standards are required, but are instead meant to add depth and breadth to classroom instruction. These connections highlight key links to various aspects of the science ecosystem, enriching the content and deepening students' understanding. While connections are provided for some standards, they are not identified for all. They are not intended to be an exhaustive list and teachers should continue to seek connections for other standards when appropriate. Below is a list of the connections that may be found throughout the document:

ELA Connections

Decisions about how to connect and integrate content should be guided by the specific contexts, disciplines, and learning objectives. Language and literacy provide students with essential tools and practices for understanding and communicating the world around them. Through speaking, drawing, writing and reading, students express their ideas and deepen their understanding particularly in subjects like science and engineering.

Mathematics Connections

Decisions about how to connect and integrate content should be driven by the specific contexts, disciplines, and learning goals. Mathematics serves as a key tool for modeling concepts in science and engineering. Science practices include skills such as counting, measuring, spatial reasoning, data analysis, multiplicative thinking and scaling, pattern recognition, and logical problem-solving—all of which are grounded in mathematical thinking.

Iowa Connections

Opportunities to teach science using topics directly relevant to our state (e.g. Mississippi River, agriculture, Iowa-specific flora and fauna, Iowa's rich geologic history, etc.) are listed throughout the standards as "Iowa Connections." These connections allow educators to use local, regional, and state-specific contexts for teaching, learning, and assessment. Educators may choose to use these as recommendations for investigation with students. Additionally, assessment developers have the opportunity to use the Iowa contexts to develop Iowa-specific examples or scenarios from which students would demonstrate their general understanding. This approach provides the opportunity for educators to draw upon Iowa's natural environment and rich history and resources in engineering design and scientific research to support student learning.

Career Connections

Exposing science students to career clusters is crucial for helping them understand the diverse opportunities available within and beyond traditional scientific fields. By exploring various career pathways early on, students can connect their academic learning to real-world applications, gaining insights into how their skills might align with specific industries such as healthcare, environmental science, or technology. This exposure not only broadens their perspectives but also enables them to make informed decisions about their future careers, motivating them to pursue education and training that aligns with their interests and the evolving demands of the workforce.

The following career clusters are identified in many of our standards: Agriculture, Food and Natural Resources, Architecture and Construction, Manufacturing, Science, Technology, Engineering, Mathematics, Health Sciences, and Information Technology.

Engineering & Technology Connections

Performance indicators for the engineering design process are intentionally embedded in all grade levels. These indicators allow students to demonstrate their ability to define problems, develop possible solutions, and improve designs. These indicators should be reinforced whenever students are engaged in practicing engineering design during instruction. Having students engage in the engineering design process will prepare them to solve challenges both in and out of the classroom. The nature of technology, broadly defined, recognizes the interaction between technology and society and raises questions about the trade-offs and values embedded within technological artifacts and systems.

Nature of Science Connections

A key goal of the Iowa Academic Standards for Science is to cultivate scientifically literate individuals who understand the nature of science. Defining features of scientific knowledge, across all disciplines, include its openness to revision in response to new evidence and that robust scientific knowledge is vetted and justified through evidence and consensus building among scientists. While the integration of scientific and engineering practices, disciplinary core ideas, and crosscutting concepts provides a foundation for teaching and learning about the nature of science, understanding these constructs requires that teachers pose questions encouraging students to reflect on the nature of science.

Teaching the Standards

Bundling

The Iowa Academic Standards for Science are not meant to be taught (or assessed) individually. Standards are meant to be bundled into units where students have the freedom to use multiple and various practices, content, and crosscutting concepts to explain a phenomenon or solve a problem. Bundles are groups of standards that are arranged to create endpoints for units of instruction. Bundles of standards can be helpful to show connections between ideas, facilitate phenomenon-driven instruction, and promote efficient use of instructional time. They form end goals for instruction at a similar scale to that of traditional curricular units. These bundles may consist of three or four standards placed cohesively in a unit of study. The following diagram gives an example for how standards may be bundled in kindergarten and 8th grade units. Notice that the bundle of standards may contain standards from different domains.

Example Kindergarten Bundle

Unit Phenomena: Iowa squirrels store nuts for winter.
Unit Driving Question: What do plants and animals need to meet their needs and survive within environments?

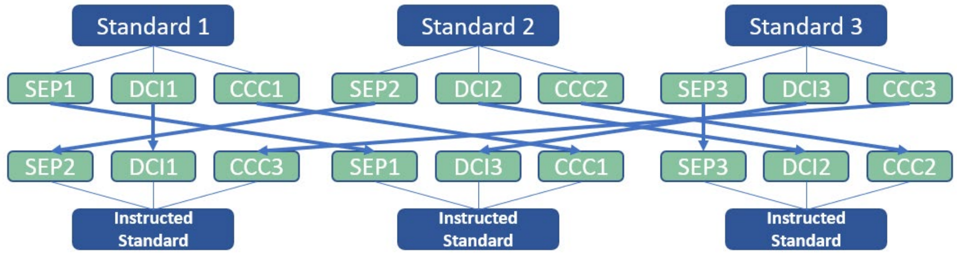
K-LS1-1	K-ESS2-1	K-ESS2-2	K-ESS2-3
	K-ESS2-4	K-ETS1-1	

Example Eighth Grade Bundle

Unit Phenomena: Iowa's soil is very fertile for growing crops.
Unit Driving Question: "How have Earth processes changed populations of organisms?"

8-ESS2-6	8-ESS2-5	8-LS4-1	8-LS4-3
	8-LS4-6	8-LS4-2	

By bundling these standards, we create the flexibility to teach the three dimensions in various combinations throughout the unit. The Iowa Academic Standards for Science serve as a framework for how these dimensions can be integrated. This approach allows students to navigate seamlessly through multiple science and engineering practices, disciplinary core ideas, and crosscutting concepts during their learning journey. The following diagram illustrates how these dimensions may be rearranged in both instruction and assessment.



It's important to note that the diagram above incorporates only the science and engineering practices, cross cutting concepts, and disciplinary core ideas found in the original standards. This may not be comprehensive enough in the listed final instructed standards to explain the phenomena. Students are likely to engage with more than just the three practices highlighted in this example. Any relevant practice, crosscutting concept, or disciplinary core idea should be integrated into instruction as needed to help students make sense of the phenomena or address the problem under study. By reconfiguring the dimensions into clearly defined standards, teachers can ensure that all specific dimensions are utilized in three-dimensional instruction throughout the unit.

Coherence from the Student Perspective

Units of study should focus on students actively making sense of relevant phenomena. Designing a classroom experience around students discovering something about the natural world requires a shift away from traditional, content-driven teaching. For instance, in a physics lesson, instructors might typically introduce concepts in a fixed, linear order—starting with displacement before velocity, velocity before acceleration, and so on. While this sequence may make sense to the teacher as a cohesive set of learning objectives, it most likely will not resonate with students in a meaningful way.

From the student's perspective, the learning process often feels like a series of isolated steps—each concept is learned simply because it precedes a more advanced idea. The emphasis is on completing tasks laid out by the teacher, with little room for student input or direction in the flow of the lesson. By designing lessons that invite students to engage in sensemaking around real-world phenomena, educators can shift this dynamic. Students start with broad questions, allowing them to guide the direction of the lesson and shape the trajectory of their learning. This approach fosters a sense of agency, enabling students to anticipate future questions and see how new information connects to what they already know.

To create learning environments aligned with three-dimensional learning, teachers must go beyond simply incorporating all three dimensions into their lessons. It's not enough for the dimensions—disciplinary core ideas, science and engineering practices, and crosscutting concepts—to coexist in the same lesson. Instead, teachers should collaborate with students in co-developing the trajectory of their investigations and the process of knowledge-building. This approach not only makes learning more relevant and engaging but also empowers students to take an active role in their own intellectual development (Reiser et al, 2017).

Integration of Engineering, Technology, and Society

The Iowa Academic Standards for Science demonstrate a commitment to incorporating engineering design into science education by elevating it to the same level as scientific inquiry. This integration spans all grade levels, from kindergarten through high school, emphasizing the importance of engineering design as a component of science instruction. There are both practical and visionary reasons for this inclusion. Providing students with a foundation in engineering design empowers them to engage with, and ultimately address, the complex societal and environmental challenges they will encounter in the future. The standards reflect this by embedding engineering design throughout the document in two key ways.

First, many of the standards across the three scientific disciplines—life science, physical science, and Earth and space science—begin with an engineering practice. In these standards, students demonstrate their understanding of scientific concepts through the application of engineering design practices. Second, the standards also feature specific engineering design expectations in each grade band (K-2, 3-5, 6-8, and 9-12). This dual approach, incorporating engineering design as both a set of practices and foundational concepts, aligns with the vision of the *Framework for K-12 Science Education*.

This integration recognizes the interactions of technology and society and raises questions about the trade-offs and values embedded within technological artifacts and systems. Because technology influences thinking and behavior, technology impacts individuals and society. Yet, through individual and collective choices, society impacts technology. Although all technologies come with trade-offs, identifying these trade offs can improve the design and use of the technologies. Despite designers' intent to solve problems, not all problems can be solved with technology.

It's important to note that while the Iowa Academic Standards for Science do not provide a comprehensive set of engineering, technology, and society standards, they do include essential concepts necessary for students to be scientifically literate citizens. These standards are designed to reflect the three main components of engineering design as outlined in the *Framework for K-12 Science Education*, and they progress in complexity at each grade level. Engineering design should not be taught in isolation but should be integrated within the context of disciplinary science content. The engineering, technology, and society standards (ETS) are not meant to stand alone; rather, they are intended to be woven into science courses, units, and lessons, reinforcing the connections between scientific concepts, engineering practices, technology, and society.

Literacy Standards for Science

Content area literacy is critical to students' post-secondary success in higher education and the workplace. To prepare students for these challenges, literacy skills must be developed across all content areas. Students expand their range when applying literacy skills to a variety of content areas because the academic discourses and disciplinary concepts in those require different approaches to reading, writing, speaking, viewing, and listening. It is through applying literacy skills in a number of content areas that students learn to integrate these skills and strategies into life experiences. Teachers in all content areas who make literacy a priority understand that learning involves making meaning. The Standards for Literacy in Science, taken from the Iowa Academic Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects are found in Appendix C.

Elementary Science

Establishing a strong foundation in science and engineering during preschool and elementary school is crucial for future success. This early education not only supports, nurtures and amplifies student's natural curiosity about the world but also equips them with the essential knowledge and skills necessary to tackle more complex science and engineering concepts introduced in later grades. As science instruction time has steadily decreased over the past twenty years, teachers face significant challenges in delivering the science and engineering experiences that preschool and elementary students need (Blank, 2013). These foundational experiences are essential for students to develop scientific mindsets, enabling them to think critically, solve problems, and navigate the challenges of an increasingly complex world. Without fundamental experiences in science in primary grades, students tend to self-select themselves out of STEM pathways in middle and high school.

The National Academies of Sciences, in their report, *Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators*, makes many recommendations to enhance elementary science education including, "District and school leaders in elementary and preschool settings should examine the amount of time and resources allocated to science and engineering instruction and then (a) develop schedules that allow a comprehensive, frequent, and consistent focus on science and engineering, (b) create coherence from preschool through elementary, and (c) allocate the necessary resources (fiscal, material, and human) to support equitable science and engineering learning opportunities" (Academies, 2022).

The following table lists the standards aligned to each grade level.

Kindergarten	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade
K-PS2-1 K-PS2-2 K-PS3-1 K-PS3-2 K-LS1-1 K-ESS2-1 K-ESS2-2 K-ESS3-1 K-ESS3-2 K-ESS3-3 K-ETS1-1 K-ETS1-2 K-ETS1-3	1-PS4-1 1-PS4-2 1-PS4-3 1-PS4-4 1-LS1-1 1-LS1-2 1-LS3-1 1-ESS1-1 1-ESS1-2 1-ETS1-1 1-ETS1-2 1-ETS1-3	2-PS1-1 2-PS1-2 2-PS1-3 2-PS1-4 2-LS2-1 2-LS2-2 2-LS4-1 2-ESS1-1 2-ESS2-1 2-ESS2-2 2-ESS2-3 2-ETS1-1 2-ETS1-2 2-ETS1-3	3-PS2-1 3-PS2-2 3-PS2-3 3-PS2-4 3-LS1-1 3-LS2-1 3-LS3-1 3-LS3-2 3-LS4-1 3-LS4-2 3-LS4-3 3-LS4-4 3-ESS2-1 3-ESS2-2 3-ESS3-1 3-ETS1-1 3-ETS1-2 3-ETS1-3	4-PS3-1 4-PS3-2 4-PS3-3 4-PS3-4 4-PS4-1 4-PS4-2 4-PS4-3 4-LS1-1 4-LS1-2 4-ESS1-1 4-ESS2-1 4-ESS2-2 4-ESS3-1 4-ESS3-2 4-ETS1-1 4-ETS1-2 4-ETS1-3	5-PS1-1 5-PS1-2 5-PS1-3 5-PS1-4 5-PS2-1 5-PS3-1 5-LS1-1 5-LS2-1 5-ESS1-1 5-ESS1-2 5-ESS2-1 5-ESS2-2 5-ESS3-1 5-ETS1-1 5-ETS1-2 5-ETS1-3

Kindergarten

Kindergartners in Iowa focus on exploring the world through observation and hands-on experiences. Students engage with fundamental concepts related to physical science, life science, and Earth science, often using their senses to gather information. It is a time for students to ask questions, make predictions, and test ideas in a simple, exploratory way. Science in kindergarten is about using first-hand investigations to spark curiosity and develop early critical thinking skills. Teachers should aim to create an environment where students feel encouraged to wonder, experiment, and share their ideas.

Kindergarten students will practice asking questions, making models, and planning simple investigations. They will look for patterns in nature, like changes in the weather, and make sense of how different things in the world are connected. Using evidence to explain their findings and sharing their ideas will help them develop a deeper understanding of how science works and how it connects back to their everyday lives.

Another point of emphasis is cross-curricular integration, particularly with English Language Arts and Mathematics. Students could engage in shared writing projects and record observations as part of their investigations, developing literacy skills like sequencing and information recall. In mathematics, students use comparative language, tallying, and simple measurements to describe their findings in support of their own quantitative reasoning.

The kindergarten standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- What can I do to make things move? What can I do to change how they move? How could I build something that moves?
- Where do animals live and why do they live there? How do plants and animals survive if we aren't there to grow and feed them?
- How does the weather change what we do? What patterns can we find in the kinds of weather we have?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-PS2-1	**Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.**	**Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers. It is appropriate to investigate the same or similar questions in groups or as a class. Through iterations they make predictions.	**Forces and Motion:** Pushes and pulls have different strengths and directions. Pushing or pulling an object can change the speed or direction of its motion and can start or stop it. When objects touch or collide, they push on one another and can change motion. Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other. Students notice the pattern of the harder the push or pull, the farther the objects move, or the faster it goes. Also, the higher an incline, the faster and farther an object moves on a ramp. Relate to familiar activities, like playing catch or moving objects on a playground, to help students make sense of how pushes and pulls affect motion in their everyday lives. Standard Boundary does not include non-contact pushes or pulls with magnets.	**Cause and Effect:** Use simple tests to find out if ideas about why things happen are correct or not.

Scientists use different ways to study the world.

RI.K.1: Ask and answer questions about key details in a text. Students can explore questions related to causes and effects of pushes and pulls, strengthening comprehension skills.

K.CC.B.4: Demonstrate awareness of counting principles (e.g., sequencing). Counting objects pushed or pulled supports understanding of one-to-one correspondence.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-PS2-2	**Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or pull.**	**Analyzing and Interpreting Data:** Test an object, system, or tool to determine if it works as intended.	**Forces and Motion:** Pushes and pulls have different strengths and directions. Pushing or pulling an object can change the speed or direction of its motion and can start or stop it. Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn. Standard Boundary: Assessment does not include friction as a mechanism for change in speed.	**Cause and Effect:** Use simple tests to find out if ideas about why things happen are correct or not.

A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-PS3-1	**Make observations to determine the effect of sunlight on Earth's surface.**	**Planning and Carrying Out Investigations:** Make observations to collect data that can be used to make comparisons.	**Conservation of Energy and Energy Transfer:** Sunlight warms the Earth's surface. Examples of Earth's surface could include sand, soil, rocks, and water. Observe how sunlight makes surfaces (like sand, soil, rocks, and water) feel warmer or cooler. Standard Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.	**Cause and Effect:** Events have causes that generate observable patterns that can be used to make predictions.

Instruction could use local examples, like how sunlight warms playground equipment, soil in fields, or water in ponds, to help students notice how sunlight affects different surfaces around Iowa.

SL.K.5: Add drawings or other visual displays to descriptions. Students can illustrate the sun's effects on objects, enhancing communication and descriptive skills.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-PS3-2	**Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on an area.**	**Constructing Explanations and Designing Solutions:** Use materials to design and build a system to make something that solves a problem. Systems can include ways to move objects, water, air etc.	**Conservation of Energy and Energy Transfer:** Sunlight warms the Earth's surface. Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.	**Cause and Effect:** Events have causes that generate observable patterns that can be used to make predictions.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-LS1-1	**Use observations to describe patterns of what plants and animals (including humans) need to survive.**	**Analyzing and Interpreting Data:** Use firsthand observations (not reading about phenomena in a book) to identify patterns in the natural and designed world in order to answer questions that can be investigated independently and solve problems that students care about.	**Organization for Matter and Energy Flow in Organisms:** All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. Examples of patterns could include that animals need to take in food but plants do not, the different kinds of food needed by different types of animals, the requirement of plants to have light, and that all living things need water.	**Patterns:** Observe and identify patterns in the natural world to explain phenomena.

Scientists look for patterns and order when making observations about the world.

Incorporate examples from Iowa's ecosystem, such as local plants and animals, to make these patterns relatable. For example, discuss how deer eat plants while sunflowers need sunlight and water. In Iowa's natural environment, animals need food to live and grow, which they get from plants or other animals. Plants, such as the crops we see across Iowa, need water and light to live and grow.

RI.K.7: Describe relationships between illustrations and text. By linking images to information, students can better understand how visuals depict plant and animal needs.

K.MD.A.1: Describe measurable attributes (e.g., length or weight). Students can observe plant growth and describe its measurable properties, building descriptive mathematics skills.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ESS2-1	**Use and share observations of local weather conditions to describe patterns over time.**	**Analyzing and Interpreting Data:** Use firsthand observations (not reading about phenomena in a book) to identify patterns in the natural and designed world in order to answer questions that can be investigated independently and solve problems that students care about.	**Weather and Climate:** Weather is a combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months. Standard Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.	**Patterns:** Observe and identify patterns in the natural world to explain phenomena.

Connect this to Iowa's seasonal changes, helping students observe local patterns, like colder temperatures in the morning during fall and winter, or comparing sunny days in summer versus cloudy days in spring.

RI.K.3: Describe connections between individuals, events, ideas, or steps. Students can identify weather patterns and describe their effects on people and nature, building sequence skills.

K.MD.B.3: Classify and count objects in categories. Students can count different types of weather events, reinforcing categorization and counting skills.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ESS2-2	**Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.**	**Engaging in Argument from Evidence:** Explain phenomena based on observations of what is happening during investigations.	**Biogeology and Human Impacts on Earth Systems** Plants and animals can affect and change their environment. Examples of plants and animals changing their environment could include a squirrel digging in the ground to hide its food and that tree roots can break concrete.	**Systems and Systems Models:** Identify parts of an object or organism, and that those parts work together in a system.

Relate this to Iowa's environment, such as how prairie plants help prevent soil erosion, how local animals like beavers build dams that change water flow in rivers and streams, or how a squirrel might dig in the soil to hide acorns.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ESS3-1	**Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.**	**Developing and Using Models:** Observe models such as labeled drawings of objects and compare to find similarities and differences.	**Natural Resources:** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. Examples of relationships could include that deer eat buds and leaves and therefore usually live in forested areas and that grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.	**Systems and System Models:** Identify parts of an object or organism, and that those parts work together in a system.

Connect to Iowa's natural resources, such as the importance of water from rivers, soil for farming, and forests that support local wildlife like deer, showing students how people and animals depend on these resources.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ESS3-2	**Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.**	**Asking Questions and Defining Problems:** Make observations to generate questions that can be investigated about the world around them.	**Natural Hazards:** Emphasis is on local forms of severe weather. Certain types of severe weather are more common in specific areas. Weather scientists, or meteorologists, predict severe weather to help communities prepare and stay safe.	**Cause and Effect:** Events have causes that generate observable patterns that can be used to make predictions.

People encounter questions about the natural world every day. People depend on various technologies in their lives; human life would be very different without technology.

Focus on Iowa's local severe weather, such as thunderstorms, tornadoes, and snowstorms, to help students make sense of how weather forecasting aids in preparing for these events.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ESS3-3	**Communicate solutions that will improve sustainability of the land, water, air, and/or other living things in the local environment.**	**Obtaining, Evaluating and Communicating Information:** Explain ideas through talking or drawing to show how things work.	**Human and Environmental Impacts on Earth Systems:** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. Examples of impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.	**Cause and Effect:** Events have causes that generate observable patterns that can be used to make predictions.

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.

Discuss how people in Iowa can make choices that protect the land, water, and air, such as recycling in local communities and conserving natural resources to help protect Iowa's environment for plants, animals, and people.

W.K.2: Use a combination of drawing, dictating, and writing to compose informative texts. Students create simple texts explaining ways to reduce environmental impact, building informative writing skills.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ETS1-1	**Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.**	**Asking Questions and Defining Problems:** Curiosity and observations lead to asking questions that can be investigated. Noticing a problem that students care about or something they want to make happen can lead to the student developing and refining a tool/ structure etc.	**Defining and Delimiting Engineering Problems:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	NA

People's needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ETS1-2	**Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**	**Developing and Using Models:** Develop a simple model based on evidence to represent a proposed object or tool.	**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.	**Structure and Function:** Students can observe how the parts of plants serve different purposes (roots, stem, flower) and the shapes of a system relate to their function (ramps, spigots, pinwheel blades)

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
K-ETS1-3	**Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**	**Analyzing and Interpreting Data:** Test an object, system, or tool to determine if it works as intended.	**Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

First Grade

First graders in Iowa use standards that emphasize foundational investigation, observation, and modeling practices to help students explore basic scientific concepts in engaging and hands-on ways. Students are encouraged to make predictions, observe patterns, and gather evidence through simple investigations at this grade level. Teachers will guide students in planning and carrying out investigations, often using familiar materials and relatable contexts, such as exploring sound with vibrating objects like tuning forks or observing light with flashlights. These activities are designed to introduce students to cause and effect, a key crosscutting concept at this grade level, by observing how changes (e.g., a vibrating object or light beam) affect outcomes.

Students are expected to explore how vibrations produce sound and how the presence of light affects the visibility of objects. By investigating how light interacts with different materials, they learn that light travels and can be blocked, transmitted, or reflected. Additionally, students make sense of how plants and animals rely on their external features for survival, growth, and meeting basic needs, as well as how the behaviors of parents and their young aid in offspring survival. Lastly, students will observe, describe, and predict patterns in the movement of objects in the sky, such as the sun, moon, and stars.

Another point of emphasis is cross-curricular integration, particularly with English Language Arts and mathematics. Students could engage in shared writing projects and record observations as part of their investigations, developing literacy skills like sequencing and information recall. In mathematics, students use comparative language, tallying, and simple measurements to describe their findings, supporting quantitative reasoning.

The first-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- What makes a sound, and how can we see sound in action? What can I do to change sound?
- How do animals and plants use their body parts to survive?
- How are parents and their children similar and different? How do young animals look like their parents but also a little different?
- What patterns do we see in the sky with the sun, moon, and stars?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-PS4-1	**Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.**	**Planning and Carrying Out Investigations:** Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question.	**Wave Properties:** Sound can make matter vibrate, and vibrating matter can make sound. Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.	**Cause and Effect:** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Science investigations begin with a question. Scientists use different ways to study the world.

Explore sounds from Iowa's environment, such as Indigenous drums, marching band instruments, or the vibrations of farm equipment.

SL.1.1: Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-PS4-2	**Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.**	**Constructing Explanations and Designing Solutions:** Make observations to construct an evidence-based explanation of natural phenomena.	**Electromagnetic Radiation:** Objects can only be seen if there is light available to illuminate them, either through an external light source or by giving off their own light. Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight.	**Cause and Effect:** Use patterns to describe phenomena potentially determining a cause & effect relationship that they can replicate.

Students can explore how farm machinery or reflective road signs become visible at night when illuminated by headlights or flashlights. This can help students make sense of the importance of light in visibility, especially in rural areas where nighttime lighting is limited.

W.1.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. SL.1.1: Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-PS4-3	**Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.**	**Planning and Carrying Out Investigations:** Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question.	**Electromagnetic Radiation:** Materials allow different amounts of light to pass through them. Some materials are transparent and allow light to pass (such as clear plastic), others are translucent and allow only some light (such as wax paper), and some are opaque and block all light, creating a dark shadow (such as cardboard). Other materials are reflective (such as a mirror) and can be used to redirect light. The focus is on using experiences with light sources, mirrors, and materials to develop the idea that light travels from place to place; no attempt is made to discuss the speed of light.	**Cause and Effect:** Simple tests can be designed to gather evidence to support or refute students' ideas about causes.

W.1.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. SL.1.1: Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-PS4-4	**Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.**	**Constructing Explanations and Designing Solutions:** Use simple tools and materials to solve a problem, and think about other ways to solve it by comparing their ideas.	**Information Technologies and Instrumentation:** People use devices, such as light, a string telephone, or a series of drum beats, to send and receive information over long distances to communicate. The focus is on using light or sound to communicate rather than the technological details of how devices work.	NA

People depend on various technologies; human life would be very different without technology to communicate over long distances.

Technologies like weather warning sirens play a critical role in keeping communities safe by alerting people through sound to severe weather, such as tornadoes.

SMP.5: Use appropriate tools strategically. 1.MD.A.1: Order three objects by length; compare the lengths of two objects indirectly by using a third object. 1.MD.A.2: Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-LS1-1	**Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.**	**Constructing Explanations and Designing Solutions:** Use materials to design a device that solves a specific problem or a solution to a specific problem.	**Structure and Function & Information Processing:** All organisms (plants and animals) have external body parts that are used for survival such as outer coverings, limbs, tails or roots. Plants have roots, stems, leaves, flowers, and fruits. Animals have different body parts to help them see, hear, move, grasp objects, protect themselves and meet their basic needs. Animals have body parts that capture and convey information needed for survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Plants also have some parts that respond to external inputs for survival, such as leaves turning towards the sun. Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclist by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and detecting intruders by mimicking eyes and ears.	**Structure and Function:** Recognize that the way things look and are built helps them do their job, like how a bird's wings are shaped for flying.

Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world. Plants and animal structures can give rise to human technology (e.g., burdock-type seed pods inspired the invention of Velcro).

In Iowa, hunters use camouflage clothing with colors and patterns that mimic the natural environment, similar to how certain animals blend in to avoid predators. Inspired by animal adaptations, this design helps hunters remain hidden in fields, forests, and prairies.

W.1.7: Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-LS1-2	**Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.**	**Obtaining, Evaluating and Communicating Information:** Examine text and media to find patterns and information about the world around us. Explain how some pictures help us make sense of science ideas. Tell or write about ideas and how things work, using drawings or models to help explain science ideas.	**Growth and Development of Organisms:** Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).	**Patterns:** Observe and identify patterns in the natural and human-designed world. The patterns can be used to describe phenomena and used as evidence.

Bobwhite quail parents engage in distraction displays, pretending to be injured to lure predators away from their vulnerable young, demonstrating behaviors that increase the chicks' chances of survival. Many songbirds fly at the predators to distract and lead the predators away from their nests.

RI.1.1: Ask and answer questions about key details in a text. RI.1.10 With prompting and support, read informational texts appropriately complex for grade 1.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-LS3-1	**Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.**	**Constructing Explanations and Designing Solutions:** Observe things in nature and use what is seen or learned from stories or videos to describe how something happens. Use simple tools and materials to solve a problem, and think about other ways to solve it by comparing ideas.	**Inheritance and Variation of Traits:** Young animals are very much, but not exactly, like their parents. Plants are very much, but not exactly, like their parents. Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. Examples of patterns could include features that plants or animals share. Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size and that a particular breed of dog looks like its parent but is not exactly the same. Standard Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.	**Patterns:** Observe and identify patterns in the natural and human-designed world. The patterns can be used to describe phenomena and used as evidence.

W.1.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

SMP.2: Reason abstractly and quantitatively. SMP.5: Use appropriate tools strategically.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-ESS1-1	**Use observations of the sun, moon, and stars to describe patterns that can be predicted.**	**Analyzing and Interpreting Data:** Use observations (firsthand or from media sources) to identify patterns and/or relationships in the natural world in order to answer scientific questions and solve problems. Compare predictions based on prior experiences to an observable event.	**The Universe and its Stars:** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set and that stars other than our sun are visible at night but not during the day. Standard Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.	**Patterns:** Observe and identify patterns in the natural and human-designed world. The patterns can be used to describe phenomena and used as evidence.

Science assumes natural events happen today as they happened in the past. The repeatability of events allows scientists to make predictions and inferences that help them support the models/ideas about the natural world.

W.1.7: Participate in shared research and writing projects (e.g., explore a number of “how-to” books on a given topic and use them to write a sequence of instructions). W.1.8: With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-ESS1-2	**Make observations at different times of year to relate the amount of daylight to the time of year.**	**Planning and Carrying Out Investigations:** Use comparative language such as faster or slower, more or less, or use tallies and/or numbers to describe and compare amounts. Standard units of measurement to describe and compare distance and size might be used.	**Earth and the Solar System:** Seasonal patterns in sunrise and sunset can be observed, described, and predicted. Emphasis is on the relative comparisons of the amount of daylight in the winter to the amount in the spring or fall. For example, the timing of sunrise and sunset in winter compared to the timing of sunrise and sunset in spring or fall. Standard Boundary: Assessment is limited to relative amounts of daylight, not quantifying hours of daylight.	**Patterns:** Observe and identify patterns in the natural and human designed world. The patterns can be used to describe phenomena and used as evidence.

Students could observe how daylight affects Iowa's daily routines and seasonal events. For example, they might track if the sun has risen or set on their ride to and from school and how daylight changes impact outdoor sports schedules or community activities. This approach helps students connect seasonal daylight changes to their lives and community activities.

SMP.4: Model with mathematics. SMP.5: Use appropriate tools strategically. 1.MD.C.4: Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-ETS1-1	**Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.**	**Asking Questions and Defining Problems:** Define a simple problem that can be solved through the development of a new or improved object or tool.	**Defining and Delimiting Engineering Problems:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	NA

People's needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-ETS1-2	**Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**	**Developing and Using Models:** Develop a simple model based on evidence to represent a proposed object or tool.	**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.	**Structure and Function:** Students can observe how the parts of plants serve different purposes (roots, stem, flower) and the shapes of a system relate to their function (ramps, spigots, pinwheel blades)

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
1-ETS1-3	**Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**	**Analyzing and Interpreting Data:** Students will test an object, system, or tool to determine if it works as intended.	**Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Second Grade

Second graders in Iowa will engage in the practices as scientists to build their proficiency in asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

Students use these practices to build their understanding and knowledge of disciplinary content that includes the structure and properties of matter, interdependent relationships & ecosystems, Earth systems: processes that shaped the Earth, and engineering design.

Students are expected to make sense concepts around what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students are also expected to compare the diversity of life in different habitats. An understanding of observable properties of materials is developed by students at this level through analysis and classification of different materials. Students are able to apply their understanding of the idea that wind and water can change the shape of the land to compare design solutions to slow or prevent such change.

Students are able to use information and models to identify and represent the shapes and kinds of land and bodies of water in an area and where water is found on Earth. The crosscutting concept of patterns; cause and effect; energy and matter; structure and function; stability and change; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for this disciplinary content.

Another point of emphasis is cross-curricular integration, particularly with English Language Arts and mathematics. Students could engage in shared writing projects and record observations as part of their investigations, developing literacy skills like sequencing and information recall. In mathematics, students use comparative language, tallying, and simple measurements to describe their findings, supporting quantitative reasoning.

The Iowa Academic Standards in Science for second grade help students ask questions, make observations, gather, analyze, and communicate explanations as they formulate evidence-based answers to questions.

Examples of Grade-Level Driving Questions

- How does land change and what are some things that cause it to change? What are some design solutions that could slow or prevent changes to the land?
- How do the properties of the materials relate to their use?
- What do plants need to grow?
- How many types of living things live in a place?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-PS1-1	**Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.**	**Planning and Carrying Out Investigations:** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**Structure and Properties of Matter:** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.	**Patterns:** Observe and identify patterns in the natural and human designed world. The patterns can be used to describe phenomena and used as evidence.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

SMP 4: Model with Mathematics 2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-PS1-2	**Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.**	**Analyzing and Interpreting Data:** Analyze data from tests of an object or tool to determine if it works as intended.	**Structure and Properties of Matter:** Different properties are suited to different purposes. Examples of properties could include, strength, flexibility, hardness, texture, and absorbency. Standard Boundary for quantitative measurements is limited to length.	**Cause and Effect:** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Many human-made products are designed by applying some knowledge of the natural world and are built using materials derived from the natural world.

Agricultural products such as corn and soybeans can be used to make food products and non-food products.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

SMP 2: Reason abstractly and quantitatively SMP 4: Model with Mathematics SMP 5: Use appropriate tools strategically 2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-PS1-3	**Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.**	**Constructing Explanations and Designing Solutions:** Use information from observations to construct an evidence-based account for natural phenomena.	**Structure and Properties of Matter:** Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces. Examples of pieces could include blocks, building bricks, or other assorted small objects.	**Energy and Matter:** Identify that objects may be composed of smaller pieces or put together into larger pieces and this can result in a change in shape.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

Manufacturing objects involves taking pieces of objects and putting them together so that they work for their intended purpose.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-PS1-4	**Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.**	**Engaging in Argument from Evidence:** Construct an argument with evidence to support a claim.	**Chemical Reactions:** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. An example of a reversible change could include freezing water then using a hair dryer to melt ice cubes. An example of an irreversible change could include cooking an egg.	**Cause and Effect:** Events have causes that generate observable patterns.

Science searches for cause and effect relationships to explain natural events.

Burning a log in a campfire or making a s'more on a campfire.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-LS2-1	**Plan and conduct an investigation to determine if plants need sunlight and water to grow.**	**Planning and Carrying Out Investigations:** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**Interdependent Relationships in Ecosystems:** Plants depend on water and light to grow. These two variables should be tested one at a time to collect evidence that both are needed. Only having sunlight OR water, but not both, will not result in plant growth. Standard Boundary is limited to testing one variable at a time.	**Cause and Effect:** Events have causes that generate observable patterns.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

SMP 2: Reason abstractly and quantitatively SMP 4: Model with Mathematics SMP 5: Use appropriate tools strategically.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-LS2-2	**Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.**	**Developing and Using Models:** Develop a simple model based on evidence to represent a proposed object or tool.	**Interdependent Relationships in Ecosystems & Developing Possible Solutions:** Animals can assist the pollination of plants or help move seeds to other locations to grow. Examples of pollination could include carrying pollen on bees' legs from flower to flower. Examples of seed dispersal by animals could include eating and spreading seeds through waste.	**Structure and Function:** The shape and stability of structures of natural (i.e., bird nests, cockleburs, furry legs, etc.) and designed (i.e., bridges, buildings, etc.) objects are related to their function(s).

Detasseling involves removing the tassel at the very top of the corn plant, mechanically and by hand, to prevent unwanted pollination. This results in the plant producing pure hybrid seeds. Also, when going for walks in prairies, fields, or the woods, sometimes humans or animals pick up cockleburs and relocate them to other areas. Burrs are used as the model for Velcro.

SMP 4: Model with Mathematics 2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

Engineering, Technology, and Manufacturing jobs often use animals as models for creating devices that serve a similar purpose.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-LS4-1	**Make observations of plants and animals to compare the diversity of life in different habitats.**	**Planning and Carrying Out Investigations:** Make observations (firsthand and from media) to collect data for making comparisons and construct an evidence-based account for natural phenomena.	**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. Standard Boundary does not include specific animal and plant names in specific habitats.	**Patterns:** Look for patterns and order when making observations about the world.

Use local Iowa habitats to identify the many different kinds of living things in an area. Include land, moving water, and still water environments.

Scientists look for patterns when making observations about the world.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

SMP 2: Reason abstractly and quantitatively SMP 4: Model with Mathematics 2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ESS1-1	**Use information from several sources to provide evidence that Earth events can occur quickly or slowly.**	**Constructing Explanations and Designing Solutions:** Make observations from several sources to construct an evidence-based account for natural phenomena.	**The History of Planet Earth:** Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly. The focus does not include quantitative measurements of timescales.	**Stability and Change:** Things may change slowly or rapidly.

Some of Iowa's landforms were the result of glaciers. These may include Loess Hills, Iowa Great Lakes. Other Iowa landforms (Backbone State Park, Ledges and Dolliver State Parks) also were impacted by glacier action. Fast changes could include tornadoes, derechos, floods, etc. Wind and water erosion could be included as sometimes fast, sometimes slow changes.

RI.2.1: Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.

SMP 4: Model with Mathematics 2.NBT.A: Understand place value.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ESS2-1	**Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.**	**Constructing Explanations and Designing Solutions:** Compare multiple solutions to a problem.	**Earth Materials and Systems & Optimizing the Design Solution:** Wind and water can change the shape of the land. Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.	**Stability and Change:** Things may change slowly or rapidly.

Iowa’s landscape has been changed due to wind events such as derechos and tornadoes. Flooding has also impacted many Iowa communities across the state in multiple years. Flooding can cause damage to crops, human-designed structures (buildings, bridges, etc.) and natural structures (river banks, shoreline, etc.) One flooding event caused fossils to be revealed (Devonian Gorge).

RI.2.9: Compare and contrast the most important points presented by two texts on the same topic.

SMP 2: Reason abstractly and quantitatively SMP 4: Model with Mathematics SMP 5: Use appropriate tools strategically 2.NBT.B.5: Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ESS2-2	**Develop a model to represent the shapes and kinds of land and bodies of water in an area.**	**Developing and Using Models:** Develop a model to represent patterns in the natural world.	**Plate Tectonics and Large-Scale System Interactions:** Maps show where things are located including the shapes and kinds of land and water in any area. Examples of the natural world might be lakes, hills, and prairies. Examples of the designed world might be dams, designed parks, and bike trails. Standard boundary does not include quantitative scaling in models.	**Patterns:** Observe and identify patterns in the natural and human-designed world. The patterns can be used to describe phenomena and used as evidence.

Iowa Department of Natural Resources (DNR) maps can be used to show land and water across the state. These maps can be used to learn more about the area in which the students live. Field trips to these local areas could be used for students to create their own maps to identify features of the area in which they live.

SL.2.5: Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

SMP 2: Reason abstractly and quantitatively SMP 4: Model with Mathematics. 2.NBT.A.3: Read and write numbers to 1,000 using base-ten numerals, number names, and expanded form.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ESS2-3	**Obtain information to identify where water is found on Earth and that it can be solid or liquid.**	**Obtaining, Evaluating and Communicating Information:** Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question.	**The Roles of Water in Earth's Surface Processes:** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	**Patterns:** Observe and identify patterns in the natural and human designed world. The patterns can be used to describe phenomena and used as evidence.

Maps (including topographic maps) of Iowa can be used to locate lakes and rivers. Pictures of bodies of water in different seasons showing water and ice can also be used.

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ETS1-1	**Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.**	**Asking Questions and Defining Problems:** Student curiosity and observations lead to the student asking questions they can investigate about the world around them. Students notices a problem they care about or something they want to make happen leading to the student developing and refining a tool/ structure etc.	**Defining and Delimiting Engineering Problems:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	NA

2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

People's needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ETS1-2	**Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.**	**Developing and Using Models:** Develop a simple model based on evidence to represent a proposed object or tool.	**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.	**Structure and Function:** Students can observe how the parts of plants serve different purposes (roots, stem, flower) and the shapes of a system relate to their function (ramps, spigots, pinwheel blades . . .)

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
2-ETS1-3	**Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**	**Analyzing and Interpreting Data:** Students will test an object, system, or tool to determine if it works as intended.	**Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	NA

W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

2.MD.D.10: Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple problems: put-together, take-apart, and compare, using information presented in a bar graph.

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Third Grade

In physical science, third-grade students will learn about balanced and unbalanced forces on the motion of an object and that the patterns of an object's motion can be observed, measured and predicted when that past motion exhibits a regular pattern. They will explore electric or magnetic interactions and apply scientific ideas about magnets to solve problems.

In life science, third-grade students explore the unique and diverse life cycles of organisms, which all share common stages of birth, growth, reproduction, and death. They learn how some animals form groups that enhance survival. They will discover that plants and animals inherit traits from their parents, with variations occurring within groups of similar organisms. Students investigate how environmental factors can influence these traits. They will also learn that variations in characteristics among individuals of the same species can provide advantages for survival and that in any habitat, some organisms thrive, while others may struggle or fail to survive, highlighting the impact of environmental changes on the plants and animals in those areas. They will also learn that fossils provide evidence of past organisms and their habitats.

In Earth and space science, third-grade students will describe typical weather conditions expected during a particular season and design solutions to reduce the impacts of weather-related hazards. They will also explore climates in different regions of the world.

Daily, hands-on experiences with science will help third graders develop models and draw conclusions about the physical and living world. By asking questions to guide their investigations and engaging in diverse experiences, they will research, record, and collect data, enhancing their understanding of physical and natural processes while strengthening their analytical skills.

The third-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- What happens to the motion of an object when balanced or unbalanced forces are applied? How can we measure, describe and predict object movement?
- What are common life cycle stages of different organisms, and how do they compare? Why do some animals form groups to help them survive? What are some traits that plants and animals inherit from their parents?
- How do environmental factors, such as climate, habitat changes, or food availability, impact the traits of plants and animals in a specific habitat? Why do some, but not all organisms thrive in a habitat?
- What are the typical weather conditions during each season, and how do they affect our daily lives currently and in the future?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-PS2-1	**Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.**	**Planning and Carrying Out Investigations:** Work together to conduct an investigation that gathers data for evidence, using fair tests with controlled variables and trials.	**Forces, Motion, and Interactions:** Balanced and unbalanced forces both act on a specific object and have both strength and a direction. An object at rest (such as a box being pushed on from all sides) usually has multiple forces acting on it, however, these forces balance to create zero net force (the box does not move). When these forces are unbalanced they can change the object's speed or direction. Objects in contact exert forces on each other. Standard Boundary is limited to one variable at a time: number, size, or direction of forces. Standard Boundary does not include quantitative force size, only qualitative and relative. Standard Boundary is limited to gravity being addressed as a force that pulls objects down	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Science investigations use a variety of methods, tools, and techniques.

3.OA.D.9: Identify arithmetic patterns (including patterns in the addition table or multiplication table), and explain them using properties of operations

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-PS2-2	**Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.**	**Planning and Carrying Out Investigations:** Make observations and/or measurements to support their explanation of a phenomenon with evidence or test a design solution.	**Forces and Motion:** The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. Standard Boundary does not include technical terms such as period and frequency	**Patterns:** Make predictions using patterns of change.

Science findings are based on recognizing patterns.

L.3.6: Acquire and use accurately grade-appropriate conversational, general academic, and domain-specific words and phrases, including those that signal spatial and temporal relationships.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-PS2-3	**Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.**	**Asking Questions and Defining Problems:** Ask questions that can be investigated and make predictions based on patterns like cause-and-effect relationships.	**Types of Interactions:** Static electricity forces and magnetic forces between two objects do not have to be in contact with each other. The size of the static electricity forces depends on the properties of each object and their distance between each other. The size of the magnetic forces depends on the properties of each object and their distance between each other, and the orientation of the magnets relative to each other. Standard Boundary is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

RI.3.3: Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to theme, sequence, and cause/effect.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-PS2-4	**Define a simple design problem that can be solved by applying scientific ideas about magnets.**	**Asking Questions and Defining Problems:** Design problems creating solutions that include criteria for success while using limited time and resources.	**Types of Interactions:** Static electricity forces and magnetic forces between two objects do not have to be in contact with each other. The size of the static electricity forces depends on the properties of each object and their distance between each other. The size of the magnetic forces depends on the properties of each object and their distance between each other, and the orientation of the magnets relative to each other. Standard Boundary is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.	NA

Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS1-1	**Develop models to describe that organisms have unique and diverse life cycles but all have in common: birth, growth, reproduction, and death.**	**Developing and Using Models:** Develop models to describe phenomena.	**Growth and Development of Organisms:** Reproduction is essential to the survival of all organisms. Plants and animals have unique and diverse life cycles. Standard Boundary of plant life cycles is limited to those of flowering plants. Standard Boundary does not include details of human reproduction.	**Patterns:** Make predictions using patterns of change.

Science findings are based on recognizing patterns.

RI.3.7: Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS2-1	**Construct an argument that some animals form groups that help members survive.**	**Engaging in Argument from Evidence:** Construct an argument using evidence.	**Social Interactions and Group Behavior:** Being in a group helps animals find food, defend themselves, and respond to changes. Groups may serve different functions and vary widely in size.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS3-1	**Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.**	**Analyzing and Interpreting Data:** Examine and interpret data using reasoning, mathematics, and/or computation in order to make sense of a phenomenon.	**Inheritance & Variation of Traits:** Many organism's traits are inherited from their parents. There are similarities and differences in these traits between offspring, their parents and siblings. Different organisms vary in how they look and function because of inherited information. There are similarities and differences in the traits between offspring, their parents, and siblings. Standard Boundary does not include genetic mechanisms of inheritance and prediction of traits. Standard Boundary is limited to non-human examples.	**Patterns:** Use similarities and differences in patterns to sort, clarify, communicate, and analyze simple rates of change in phenomena or designed products.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS3-2	**Use evidence to support the explanation that traits can be influenced by the environment.**	**Constructing Explanations and Designing Solutions:** Use evidence (e.g., measurements, observations, patterns) to support an explanation.	**Inheritance & Variation of Traits:** Some organism's traits are a result of interactions with their environment and some organism's traits involve both inheritance and their environment. Some organism's traits are a result of interactions with their environment, such as a pet dog becoming overweight when given too much food and little exercise.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Iowa farms use a variety of agriculture practices (ex: crop rotation, tiling, etc.).

Students could explore careers in agriculture and animal health.

3.NBT.A.3: Use place value understanding to round whole numbers. Grouping and counting traits supports basic data analysis skills.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS4-1	**Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.**	**Analyzing and Interpreting Data:** Examine and interpret data using reasoning, mathematics, and/or computation in order to make sense of a phenomenon.	**Evidence of Common Ancestry and Diversity:** Fossils provide evidence that plants and animals that once lived long ago on Earth are no longer found anywhere. Fossils provide evidence about the types of organisms that lived long ago and the characteristics of their environments.	**Scale, Proportion, and Quantity:** Explain that natural things can be very small or very big and can last for a short time or a long time.

Fossil evidence found in Iowa can be used as examples, such as the Iowa Fossil Prairie, Devonian Fossil Gorge or Mahaska Mammoth.

Paleontologists study ancient life through various methods including using fossils.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS4-2	**Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.**	**Constructing Explanations and Designing Solutions:** Use evidence (e.g., measurements, observations, patterns) to support an explanation.	**Natural Selection:** Sometimes differences in traits among individuals of the same species can provide advantages for survival, finding mates, and reproducing, such as a plant with larger thorns or an animal with better camouflage being less likely to be noticed by predators.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS4-3	**Construct an argument with evidence that in a particular habitat, some organisms can survive well, some survive less well, and some cannot survive at all.**	**Engaging in Argument from Evidence:** Construct an argument using evidence, data, and/or a model.	**Adaptation:** Organisms in their habitat make up a system in which parts depend on each other. The environment affects these systems.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Iowa plants and animals live in specific habitats such as cactus in Eddyville Sand Dunes or Black Squirrels living in Council Bluffs.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-LS4-4	**Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.**	**Engaging in Argument from Evidence:** Make a claim citing relevant evidence to support a solution.	**Ecosystem Dynamics, Functioning, and Resilience & Biodiversity and Humans:** Populations live in a variety of habitats, and changes to that habitat, such as land and water characteristics, temperature, food, and other organisms, affect the organisms living there. Standard Boundary is limited to a single environmental change.	**Systems and System Models:** Describe a system by explaining its parts and how they work together.

The introduction of invasive species, such as Zebra mussels in Iowa's waterways or Emerald Ash Borer to Iowa's communities, can be used as examples of changes to an environment which then affect the organisms living there.

Naturalists and conservation officers work to maintain Iowa's natural ecosystems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ESS2-1	**Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.**	**Analyzing and Interpreting Data:** Represent data in tables and/or various graphical displays to show patterns and relationships.	**Weather and Climate:** Scientists record weather patterns including average temperature, precipitation, and wind direction across different times and places. This data allows predictions to be made about the weather in the future. Standard Boundary of graphical displays is limited to pictographs and bar graphs.	**Patterns:** Make predictions using patterns of change.

Recorded data from Iowa weather services.

Meteorologists and Climatologists study weather to help keep us safe.

3.MD.B.4: Generate measurement data and show it on a line plot. Tracking weather data helps students understand measurement and graphing.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ESS2-2	**Obtain and combine information to describe climates in different regions of the world.**	**Obtaining, Evaluating, and Communicating Information:** Look at various texts and reliable sources to support their science and engineering activities. They will combine information from written texts, tables, diagrams, and charts to describe phenomena or solutions to design problems.	**Weather and Climate:** Climate describes a range of an area's typical weather conditions and how much those conditions vary over years.	**Patterns:** Make predictions using patterns of change.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ESS3-1	**Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.**	**Engaging in Argument from Evidence:** Make a claim citing relevant evidence to support a solution.	**Natural Hazards:** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones).

Reviewing and evaluating solutions such as flood walls along Iowa river banks, snow fences on roads, or application of salt and sand on icy roads can be used to determine the effectiveness of reducing the impact of weather-related hazards.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ETS1-1	**Define a simple design problem, reflecting a need or a want, that includes specified criteria for success and constraints on materials, time, or cost.**	**Asking Questions and Defining Problems:** Define simple design problems and create solutions that include criteria for success while using limited time and resources.	**Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

People’s needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ETS1-2	**Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**	**Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**Developing Possible Solutions:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
3-ETS1-3	**Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**	**Planning and Carrying Out Investigations:** Work together to conduct an investigation that gathers data for evidence, using fair tests with controlled variables and trials.	**Developing Possible Solutions & Optimizing the Design Solution:** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Fourth Grade

In physical science, students will learn that energy causes change like movement, lighting up, and heating up. The faster an object moves, the more energy it has. Energy can travel as sound, light, heat, or electricity. When objects collide, energy can change form, like turning into sound or heat. We can also convert energy from one form to another, like using electricity to power lights or heat food. Students will also learn that waves help us see and make things move. Waves have patterns like amplitude (how big they are) and wavelength (how long they are), and these patterns can make objects move. We can see things because light waves bounce off objects and enter our eyes. Waves can also carry information, like sound in phones or pictures on TV.

In life science, students will learn that plants and animals have body parts inside and outside that help them survive, grow, and behave. Animals use their senses to gather information, their brains to process it, and they respond in different ways to stay safe and meet their needs.

In Earth and space, students will learn that rocks and fossils in the ground show how the Earth has changed over time. Weathering and erosion from water, ice, wind, or plants can shape the land. We can also see patterns in Earth's features, like mountains, valleys, and rivers, that help us make sense of how the Earth's surface changes. They will also learn that energy and fuels come from natural resources, but using them can harm the environment. We can find solutions to reduce our impact on the Earth and protect people from natural events.

The fourth-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- How does energy make things move, light up, or heat up?
- How can energy change from one form to another?
- How does energy travel as sound, light, heat, or electricity?
- What patterns in Earth's features, like mountains and rivers, help us make sense of how the surface changes?
- What solutions can we find to reduce our impact on the Earth and protect people from natural events like floods or storms?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS3-1	**Use evidence to construct an explanation relating the speed of an object to the energy of that object.**	**Constructing Explanations and Designing Solutions:** Use a variety of evidence to construct an explanation or design a solution to a problem.	**Definitions of Energy:** The faster an object moves, the more energy it has, without needing to measure or define energy precisely. Standard Boundary does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.	**Energy and Matter:** Explain the relationship of how energy can move from one place to another and from one object to another in different ways.

RL.4.1: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific details from the text. W.4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS3-2	**Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.**	**Planning and Carrying Out Investigations:** Plan and carry out an investigation, controlling variables and gathering data. Use the data as evidence to explain something or test a solution.	**Definitions of Energy & Conservation of Energy and Energy Transfer:** Energy exists in forms like motion, sound, light, and heat. When objects collide, energy transfers between them, changing their motion and warming the surrounding air while producing sound. Light is a form of energy that can transfer energy from one place to another. Energy can be transferred from one place to another using electric currents. These currents can create motion, sound, heat, or light. Electric currents are often created by converting motion energy into electrical energy. Standard Boundary does not include quantitative measurements of energy.	**Energy and Matter:** Explain the relationship of how energy can move from one place to another and from one object to another in different ways.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS3-3	**Ask questions and predict outcomes about the changes in energy that occur when objects collide.**	**Asking Questions and Defining Problems:** Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	**Definitions of Energy, Conservation of Energy and Energy Transfer, & Relationship Between Energy and Forces:** Energy can be moved from place to place by moving objects. When objects collide, contact forces transfer energy between them, resulting in changes to their motions. Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. Standard Boundary does not include quantitative measurements of energy.	**Energy and Matter:** Explain the relationship of how energy can move from one place to another and from one object to another in different ways.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS3-4	**Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.**	**Constructing Explanations and Designing Solutions:** Use a variety of evidence to construct an explanation or design a solution to a problem.	**Conservation of Energy and Energy Transfer, Energy in Chemical Processes and Everyday Life, & Defining Engineering Problems:** Producing energy involves converting stored energy into a usable form, such as devices that convert motion energy into electrical energy or use stored energy to create motion, light, or sound. Standard Boundary should be limited to devices that convert motion energy to electric energy or use stored energy to cause motion, or produce light or sound.	**Energy and Matter:** Explain the relationship of how energy can move from one place to another and from one object to another in different ways.

Engineers improve existing technologies or develop new ones.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS4-1	**Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.**	**Developing and Using Models:** Create or improve a model, using evidence, that shows how different things are connected in events that happen often and regularly.	**Wave Properties:** Waves are regular patterns of motion created by disturbing the surface of water. These waves have characteristics such as wavelength and amplitude. As waves travel across deep water, the water moves up and down in place without moving forward, except when the waves reach the shore or beach. Waves of the same type can vary in amplitude, which is the height of the wave, and wavelength, which is the distance between wave peaks. Standard Boundary does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.	**Patterns:** Use similarities and differences in patterns to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.

Science findings are based on recognizing patterns in nature.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS4-2	**Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.**	**Developing and Using Models:** Develop or improve a model, using evidence, that shows how different things are connected in events that happen often and regularly.	**Electromagnetic Radiation:** An object becomes visible when light reflects off its surface and enters our eyes, allowing us to see it. Standard Boundary does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-PS4-3	**Generate and compare multiple solutions that use patterns to transfer information.**	**Constructing Explanations and Designing Solutions:** Use scientific ideas to create and test different designs that solve a problem and they will compare designs to see which one works best based on specific criteria and constraints.	**Information Technologies and Instrumentation & Optimizing the Design Solution:** Information in digital form can be sent over long distances, and technology helps change this information back into something we can understand, like sounds or words. Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.	**Patterns:** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products.

Knowledge of relevant scientific concepts and research findings is important in engineering.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-LS1-1	**Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.**	**Engaging in Argument from Evidence:** Make a strong argument using facts and examples. Use data to see how one thing can cause another.	**Structure and Function:** Plants and animals possess both internal and external structures that support various functions such as growth, survival, behavior, and reproduction. Instruction will focus on the examination of macroscopic structures in plant and animal systems that can be observed without the aid of a microscope. Examples of structures could include: thorns, stems, roots, colored petals, heart, lung, brain, and skin.	**Systems and System Models:** Describe a system by explaining its parts and how they work together.

W.4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Variety of plants and animals include: only some trees have leaves that change color, deer shed their antlers, beavers log wood, owl pellets show a unique eating/digestion process.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-LS1-2	**Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.**	**Developing and Using Models:** Create a diagram or simple model to show a proposed object, tool, or process, and use it to test how things affect each other in a natural or designed system.	**Information Processing:** Animals have different sense receptors that are specialized to gather specific types of information, which the brain processes. These senses help animals be aware of their environment and use their memories and perceptions to make decisions. Animal and human brains process what they see, hear, touch, smell, or taste to make decisions and take actions. Standard Boundary does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.	**Systems and System Models:** Describe a system by explaining its parts and how they work together.

Squirrels use their tails for balance. Birds call to other birds when there is danger.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ESS1-1	**Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.**	**Constructing Explanations and Designing Solutions:** Use evidence to help explain or design a solution to a problem.	**The History of Planet Earth:** Local, regional, and global rock formations reflect changes over time caused by Earth’s forces, such as earthquakes. Identify patterns in rock layers and fossil types to make sense of the chronological order of geological events. Standard Boundary does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Standard Boundary is limited to relative time.	**Patterns:** Use patterns as evidence to support explanations.

Science assumes consistent patterns in natural systems.

W.4.8: Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Devonian Fossil Gorge, Rockford Fossil Prairie, limestone outcroppings are potential local connections.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ESS2-1	**Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.**	**Planning and Carrying Out Investigations:** Plan and carry out an investigation, controlling variables and gathering data. Use the data as evidence to explain something or test a solution.	**Earth Materials and Systems & Biogeology:** Rainfall and other natural forces shape the land and influence the types of living organisms in a region. The processes of weathering and erosion, including the effects of factors such as water, ice, wind, vegetation, and gravity, play a significant role in breaking down rocks and soil. Make sense of a specific type of weathering or erosion and its impact on the environment. Explore how living things affect the physical characteristics of their regions, investigating various environmental factors that influence these changes. Standard Boundary is limited to a single form of weathering or erosion.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

MP.2: Reason abstractly and quantitatively. MP.4: Model with mathematics.

There are lots of examples of where weathering and erosion play out in Iowa including Carter Lake, Loess Hills, and erosion of stream banks. Farmers use many agricultural practices that reduce erosion.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ESS2-2	**Analyze and interpret data from maps to describe patterns of Earth's features.**	**Analyzing and Interpreting Data:** Analyze and interpret data using reasoning and mathematics to make sense of something, then compare data from different groups to find similarities and differences in their results.	**Plate Tectonics and Large-Scale System Interactions:** Patterns of natural features and events on Earth, including mountain ranges, ocean trenches, ocean floor structures, earthquakes, and volcanoes.	**Patterns:** Use patterns as evidence to support explanations.

R.I.4.7: Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on web pages) and explain how the information contributes to comprehension of the text.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ESS3-1	**Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.**	**Obtaining, Evaluating, and Communicating Information:** Look at various texts and reliable sources to support their science and engineering activities. They will combine information from written texts, tables, diagrams, and charts to explain phenomena or solutions to design problems.	**Natural Resources:** Energy and fuels come from natural sources, and using them affects the environment in different ways. There are two types of energy resources: renewable and non-renewable. Renewable resources, like wind energy, hydropower (from dams), and sunlight, can be replaced over time. In contrast, non-renewable resources, such as fossil fuels and fissile materials, are limited.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Phenomena include abandoned coal mines in Iowa, wind turbines, dams, and ethanol production and their use.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ESS3-2	**Generate and compare multiple solutions to reduce the impacts of natural Earth hazards on humans.**	**Constructing Explanations and Designing Solutions:** Use scientific ideas to create and test different designs that solve a problem and they will compare designs to see which one works best based on specific criteria and constraints.	**Natural Hazards & Designing Solutions to Engineering Problems:** A variety of natural hazards, such as earthquakes, floods, tsunamis, and volcanic eruptions, result from natural processes. Humans cannot completely eliminate these hazards, they can take steps to reduce their impacts. Standard Boundary is limited to earthquakes, floods, tsunamis and volcanic eruptions.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.

Iowans can experience tornadoes, forest fires, droughts, floods, and erosion.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ETS1-1	**Define a simple design problem, reflecting a need or a want, that includes specified criteria for success and constraints on materials, time, or cost.**	**Asking Questions and Defining Problems:** Define simple design problems and create solutions that include criteria for success while using limited time and resources.	**Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

People's needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ETS1-2	**Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**	**Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**Developing Possible Solutions:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
4-ETS1-3	**Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**	**Planning and Carrying Out Investigations:** Work together to conduct an investigation that gathers data for evidence, using fair tests with controlled variables and trials.	**Developing Possible Solutions & Optimizing the Design Solution:** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	NA

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Fifth Grade

Physical science topics for 5th grade students focus on the idea that matter is made of particles too small to be seen. They develop an understanding that regardless of the type of change that matter undergoes, the total mass of matter is conserved.

Life science standards focus on how matter and energy flows through the environment. Students explore how plants get the materials they need for growth chiefly from air and water. Using models, students describe the movement of nutrients and energy through an ecosystem.

Earth science centers on exploring Earth and space systems. Using models, students are able to relate the interactions between Earth systems (geosphere, hydrosphere, atmosphere, biosphere). Students develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Fifth grade students will demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

The fifth-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- When matter changes, how does its weight change?
- How does matter cycle through ecosystems?
- Where does the energy in food come from and what is it used for?
- How do lengths and directions of shadows or relative lengths of day and night change from day to day?
- How does the appearance of stars change in different seasons?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS1-1	**Develop a model to describe that matter is made of particles too small to be seen.**	**Developing and Using Models:** Create and use models to describe phenomena.	**Structure and Properties of Matter:** All matter (solid, liquid, or gas) is made of particles (atoms) too small to be seen. Standard Boundary does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.	**Scale, Proportion, and Quantity:** Use measurements of mass, volume, temperature and time to explain the size and life span of natural things.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS1-2	**Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.**	**Using Mathematics and Computational Thinking:** Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.	**Structure and Properties of Matter & Chemical Reactions:** During any physical or chemical change, the total mass of the products equals the mass of the reactants. Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances. Standard Boundary does not include distinguishing mass and weight.	**Scale, Proportion, and Quantity:** Use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.

Science assumes consistent patterns in natural systems.

5.MD.C: Geometric measurement: Geometric measurement: understand concepts of volume and relate volume to multiplication and addition.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS1-3	**Make observations and measurements to identify materials based on their properties.**	**Planning and Carrying Out Investigations:** Make observations and take measurements for use as evidence for an explanation.	**Structure and Properties of Matter:** Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.	**Scale, Proportion, and Quantity:** Use measurements of mass, volume, temperature and time to explain the size and life span of natural things.

5.MD.C: Geometric measurement: Understand concepts of volume and relate volume to multiplication and addition.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS1-4	**Conduct an investigation to determine whether the mixing of two or more substances results in new substances.**	**Planning and Carrying Out Investigations:** Plan and conduct investigations using fair tests and best practice. Data and evidence collected will be used to explain a phenomenon that supports a solution.	**Chemical Reactions:** When two or more different substances are mixed, a new substance with different properties may be formed.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS2-1	**Support an argument that the gravitational force exerted by Earth on objects is directed down.**	**Engaging in Argument from Evidence:** Construct and/or support an argument with evidence, data, and/or a model.	**Types of Interactions:** The force of gravity pulls objects toward the center of the Earth. “Down” is a local description of the direction that points toward the center of the spherical Earth. Standard Boundary does not include mathematical representation of gravitational force.	**Cause and Effect:** Find and test cause-and-effect relationships to help explain why things change.

W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-PS3-1	**Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.**	**Developing and Using Models:** Create and use models to describe phenomena. Examples of models could include diagrams and flowcharts.	**Energy in Chemical Processes and Everyday Life & Organization for Matter and Energy Flow in Organisms:** The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water).	**Energy and Matter:** Explain how energy can move from one place to another and from one object to another in different ways.

There are many careers in the Agricultural, Food, and Natural Resources career cluster such as a botanist, farmer, environmental scientist, and forestry engineer.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-LS1-1	**Support an argument that plants get the materials they need for growth chiefly from air and water.**	**Engaging in Argument from Evidence:** Construct and/or support an argument with evidence, data, and/or a model.	**Organization for Matter and Energy Flow in Organisms:** Energy created by plants is through the synthesis of non-living components (air, water, sunlight, etc.) and not from soil. Plant matter and energy within plants can cycle into, out of and within systems.	**Energy and Matter:** Make sense of the basic concept of matter conservation and can explain how energy can move between objects.

Iowa has many plants and animals that are native to its prairie lands (ex: native grasses, red-winged blackbird, etc.). Energy and matter cycle through this prairie ecosystem.

There are many careers in the Agricultural, Food, and Natural Resources career cluster such as farmer, agronomist, or county conservationist.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-LS2-1	**Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.**	**Developing and Using Models:** Develop a model to describe phenomena.	**Interdependent Relationships in Ecosystems & Cycles of Matter and Energy Transfer in Ecosystems:** Determine that an ecosystem is a system of interdependence among living things (producers, consumers, and decomposers) and the non-living things in the same place. They should recognize that energy created by plants through the synthesis of non-living components (air, water, sunlight, etc.) cycles through the system from organism to organism. Matter (atoms and molecules) can also be cycled through the living and nonliving components of an ecosystem. Standard Boundary does not include molecular explanations.	**Systems and System Models:** A system can be described in terms of its components and their interactions.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ESS1-1	**Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.**	**Engaging in Argument from Evidence:** Construct and/or support an argument with evidence, data, and/or a model.	**The Universe and its Stars:** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. Standard Boundary is limited to relative distances, not sizes, of stars. Standard Boundary does not include other factors that affect apparent brightness (such as stellar masses, age, stage).	**Scale, Proportion, and Quantity:** Use measurements of mass, volume, temperature and time to explain the size and life span of natural things.

W.5.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

Iowa has strong ties with NASA through the Iowa Space Grant Consortium. Several astronauts have either lived in, or went to school in Iowa such as Peggy Whitson, Clayton Anderson, Raja Chari, Walter Cunningham, Laurel Clark, George Nelson, Dale Gardner, James Kelly, and Loren Shiver.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ESS1-2	**Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.**	**Analyzing and Interpreting Data:** Analyze and interpret data to make sense of something, then compare data from different groups to find similarities and differences in their results.	**Earth and the Solar System:** Examine the nearest and most familiar bodies to Earth (sun and moon) and consider the observable effects and predictable patterns they have on Earth. Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months. Standard Boundary does not include the causes of seasons.	**Patterns:** Use observations of patterns as evidence to support explanations and make predictions.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ESS2-1	**Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.**	**Developing and Using Models:** Develop a model (using an analogy, example, or representation) to describe a scientific principle or design solution and will use the model to test cause-and-effect relationships or system interactions.	**Earth Materials and Systems:** Identify the properties of Earth's major systems (geosphere, hydrosphere, atmosphere, and biosphere) and how they interact with one another. Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system. Standard Boundary is limited to the interactions of two systems at a time.	**Systems and System Models:** A system can be described in terms of its components and their interactions.

There are many careers in the Agricultural, Food, and Natural Resources career cluster such as farmer, agronomist, or county conservationist.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ESS2-2	**Describe and graph the amounts of saltwater and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.**	**Using Mathematics and Computational Thinking:** Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.	**The Roles of Water in Earth's Surface Processes:** Nearly all of Earth's available water is in the ocean. Most freshwater is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. Standard Boundary is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.	**Scale, Proportion, and Quantity:** Use measurements of mass, volume, temperature and time to explain the size and life span of natural things.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ESS3-1	**Obtain and combine information about ways individuals and communities use science ideas to protect the Earth's resources and environment.**	**Evaluating, and Communicating Information:** Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.	**Human and Environmental Impacts on Earth Systems:** Activities in agriculture, industry, and everyday life have had effects on land, flora, fauna, bodies of water, air, and even outer space, but individuals and communities are helping to protect Earth's resources and environments.	**Systems and System Models:** A system can be described in terms of its components and their interactions.

Science findings are limited to questions that can be answered with empirical evidence.

There are many careers in the Agricultural, Food, and Natural Resources career cluster such as farmer, agronomist, or county conservationist.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ETS1-1	**Define a simple design problem, reflecting a need or a want, that includes specified criteria for success and constraints on materials, time, or cost.**	**Asking Questions and Defining Problems:** Define simple design problems and create solutions that include criteria for success while using limited time and resources.	**Defining and Delimiting Engineering Problems:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

People's needs and wants change over time, as do their demands for new and improved technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ETS1-2	**Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**	**Constructing Explanations and Designing Solutions:** Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**Developing Possible Solutions:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared based on how well each one meets the specified criteria for success or how well each takes the constraints into account.	NA

Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
5-ETS1-3	**Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**	**Planning and Carrying Out Investigations:** Work together to conduct an investigation that gathers data for evidence, using fair tests with controlled variables and trials.	**Developing Possible Solutions & Optimizing the Design Solution:** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Middle School Science

In Iowa, middle school students at each grade level explore concepts from life science, physical science, Earth and space science as well as engineering and technology content domains. Using an integrated approach at each grade level and aligning standards to specific grades ensures that students do not miss out on vital areas of science during these formative years. A deep understanding of scientific concepts requires students to engage with these ideas over an extended period, allowing them to explore their interconnections and develop a comprehensive grasp of the subject matter. This developmental approach is embodied in the concept of learning progressions for middle school. If mastering core scientific principles is the goal of education, then thoughtfully designed learning progressions serve as a roadmap, guiding students on the journey to achieve that goal (National Research Council, 2012).

Arranging standards in an integrated, conceptual sequence is developed to enhance student interest and engagement over the years, as they encounter various topics in a cohesive manner. By combining complementary domains, students make sense of phenomena that bridge multiple areas of science, highlighting the interconnectedness of the content. These authentic connections foster a deeper understanding of relevant phenomena, making learning more meaningful and ultimately boosting overall scientific literacy.

The following table lists the standards aligned to each grade level.

6th Grade	7th Grade	8th Grade
6-PS1-4	7-PS2-1	8-PS1-1
6-PS1-6	7-PS2-2	8-PS1-2
6-PS3-3	7-PS2-3	8-PS1-3
6-PS4-1	7-PS2-4	8-PS1-5
6-PS4-2	7-PS2-5	8-LS1-5
6-PS4-3	7-PS3-1	8-LS1-6
6-LS1-1	7-PS3-2	8-LS1-7
6-LS1-2	7-PS3-4	8-LS3-1
6-LS1-3	7-PS3-5	8-LS3-2
6-LS1-8	7-LS1-4	8-LS4-1
6-ESS1-4	7-LS2-1	8-LS4-2
6-ESS2-1	7-LS2-2	8-LS4-3
6-ESS2-2	7-LS2-3	8-LS4-4
6-ESS2-3	7-LS2-4	8-LS4-5
6-ESS3-1	7-LS2-5	8-LS4-6
6-ESS3-2	7-ESS1-1	8-ESS2-5
6-ETS 1-1	7-ESS1-2	8-ESS2-6
6-ETS 1-2	7-ESS1-3	8-ESS3-3
6-ETS 1-3	7-ESS2-4	8-ESS3-4
6-ETS 1-4	7-ETS 1-1	8-ESS3-5
	7-ETS 1-2	8-ETS 1-1
	7-ETS 1-3	8-ETS 1-2
	7-ETS 1-4	8-ETS 1-3
		8-ETS 1-4

Sixth Grade

Sixth grade students in Iowa explore key science concepts across Earth and space, physical, and life sciences, as well as engineering and technology practices. Students observe changes in states of matter and thermal energy transfer, using models to explain phenomena and design devices for controlling energy. Through wave models, students learn about energy in sound and light, as well as digital communication. In life science, students investigate the structure-function relationship in cells and body systems. In Earth science, students examine the geologic time scale, Earth's cycles, plate tectonics, and the distribution of natural resources. The sixth-grade standards emphasize scientific practices such as modeling, data analysis, and constructing explanations to make sense of the world around them.

The sixth-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- How does a thermos keep drinks hot or cold?
- How can sound travel through walls or water, and what happens when light hits a mirror or glass?
- How do parts of cells interact with the body as a whole?
- What might happen to Earth's surface if plates beneath it are constantly moving?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS1-4	**Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.**	**Developing and Using Models:** Develop a model to predict and describe phenomena and unobservable features.	**Structure and Properties of Matter & Definitions of Energy:** "Heat" is often used to describe both the internal thermal motion of atoms within a substance (like the "heat" in a hot cup of coffee) and the radiant energy itself (like the "heat" from the sun), but in science, "heat" specifically refers to the transfer of thermal energy between objects at different temperatures. Gasses and liquids are made of moving molecules or stable atoms. Examples of particles are molecules or stable atoms, and examples of pure substances include water, carbon dioxide, and helium. In liquids, molecules are in constant contact, while as a gas, they are far apart except during collisions. In solids, atoms are closely packed and vibrate in place without changing position. Changes of state due to temperature or pressure variations can be described and predicted using models of matter.	**Cause and Effect:** Students can use cause and effect relationships to predict phenomena and systems.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS1-6	**Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.**	**Constructing Explanations and Designing Solutions:** Use the design cycle to construct and/or implement a solution that meets specific design criteria and constraints.	**Chemical Reactions:** When discussing chemical reactions, some release energy (exothermic), while others absorb energy (endothermic). This allows for the design of devices that can control the transfer of energy to the environment by manipulating factors like the type and concentration of the reacting substances; examples include dissolving ammonium chloride or calcium chloride. Standard Boundary is limited to the criteria of amount, time, and temperature of substance in testing the device.	**Energy and Matter:** The transfer of energy can be tracked as energy flows through a designed or natural system.

Iowa road crews utilize salt in the winter to melt snow, making our roads usable.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS3-3	**Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	**Definitions of Energy & Conservation of Energy and Energy Transfer:** Temperature reflects the average kinetic energy of matter particles, with the total system energy depending on the matter's type, state, and quantity. Energy is spontaneously transferred out of hotter regions or objects and into colder ones. Standard Boundary does not include calculating the total amount of thermal energy transferred.	**Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS4-1	**Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.**	**Using Mathematics and Computational Thinking:** Use mathematical representations and concepts to figure out scientific and engineering questions and problems.	**Wave Properties:** A simple wave has a repeating pattern characterized by its wavelength, frequency, and amplitude. When describing waves, it's important to use both qualitative observations and quantitative measurements to make sense of their properties. Standard Boundary does not include electromagnetic waves and is limited to standard repeating waves.	**Patterns:** Use graphs, charts, and images to identify patterns in data.

Science knowledge is based upon logical and conceptual connections between evidence and explanations.

SMP 4: Model with mathematics: Graphs are charts are mathematical representations of scientific concepts such as waves, amplitude, and energy.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS4-2	**Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.**	**Developing and Using Models:** Develop and use a model to predict and/or describe phenomena and unobservable features. Examples of models include drawings, simulations, and written descriptions.	**Electromagnetic Radiation:** When light hits an object, it can either bounce off (reflected), be taken in (absorbed), or pass through (transmitted), depending on what the object is made of and the light's color. This concept involves both light and mechanical waves. Light travels in straight lines but bends at surfaces where different transparent materials meet, like air and water or air and glass. The wave model of light helps us make sense of how light behaves, including its brightness, color, and how it bends when passing between different materials. Standard Boundary is limited to qualitative applications pertaining to light and mechanical waves.	**Structure and Function:** Structures can be designed to serve particular functions by considering properties of different materials, and how materials can be shaped and used.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-PS4-3	**Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.**	**Obtaining, Evaluating, and Communicating Information:** Integrate qualitative and/or quantitative information presented in graphs or charts to provide clear understanding of claims and findings.	**Information Technologies and Instrumentation:** Digitized signals, which are sent as wave pulses, are a reliable method for sharing information. Waves can be used for communication, like sending light pulses through fiber optic cables, using radio waves in Wi-Fi devices, and converting binary data into sound or text on a computer. Standard Boundary does not include binary counting or the specific mechanism of any given device.	**Structure and Function:** Structures can be designed to serve particular functions by considering properties of different materials, and how materials can be shaped and used.

Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

Technological advances and the progress of science influence each other.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-LS1-1	**Conduct an investigation to provide evidence that living things are made of cells; either one cell or many, different numbers and types of cells.**	**Plan and Conduct an Investigation:** Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	**Structure and Function:** All living things are made of at least one cell (the smallest unit of life). Cells can be many and varied in an organism.	**Scale, Proportion and Quantity:** Phenomena that can be observed at one scale may not be observable at another scale.

Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-LS1-2	**Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.**	**Develop and/or Use a Model:** Develop and use a model to describe a phenomenon.	**Structure and Function:** Cells function as a system. Special structures within the cells such as the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall are each responsible for a specific function. Standard Boundary of organelle structure/function relationships is limited to the cell wall and cell membrane, the function of the other organelles is limited to their relationship to the whole cell. Standard Boundary does not include the biochemical function of cells or cell parts.	**Structure and Function:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-LS1-3	**Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.**	**Engage in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation or solution for something you observe or a problem.	**Structure and Function:** In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems. Standard Boundary does not include the mechanism of one body system independent of others and is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.	**Systems and System Models:** Systems typically work as one part of a whole in order to complete a function.

Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Our rich agricultural landscape in Iowa provides evidence of various body systems that interact as subsystems of the functioning organism. For example, cows have one stomach with four distinct compartments that work together to digest and distribute nutrients (digestive system).

Careers in the medical field tie directly to this standard (doctors, physical therapists, occupational therapists, speech therapists, nurses). Elmer L. DeGowin MD, an Iowan, developed in 1939, modern-day blood banking which demonstrated that it is safe to refrigerate, ship, and use banked blood.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-LS1-8	**Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.**	**Obtaining, Evaluating, and Communicating Information:** Gather, read, and synthesize information from multiple appropriate sources.	**Information Processing:** Each sensory receptor responds to electromagnetic, mechanical, and chemical inputs, transmitting signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. Standard Boundary does not include mechanisms for the transmission of this information.	**Cause and Effect:** Use cause and effect relationships to predict phenomena and systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS1-4	**Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's history.**	**Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on reliable evidence from multiple sources (including the students' own experiments).	**The History of Planet Earth:** The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples can include the formation of mountain chains and ocean basins, the change over time or extinction of particular living organisms, or significant volcanic eruptions. Standard Boundary does not include recalling the names of specific periods or epochs and events within them.	**Scale, Proportion and Quantity:** Time, space, and energy can be studied using models to examine systems that are very large or very small.

The Devonian Gorge provides evidence of rock strata and geological time scale in Iowa.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS2-1	**Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.**	**Developing and Using Models:** Develop a model to predict and/or describe phenomena and unobservable features.	**Earth's Materials and Systems:** All Earth's processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the Sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation which act together to form minerals and rocks through the cycling of Earth's materials. Standard Boundary does not include the identification and naming of minerals.	**Stability and Change:** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS2-2	**Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.**	**Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on reliable evidence from multiple sources (including the students' own experiments).	**Earth's Materials and Systems and The Role of Water in Earth's Surface Processes:** The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. Students should focus on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.	**Scale, Proportion and Quantity:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Various natural events in Iowa (e.g. flooding or frost boils) provide evidence for geoscience processes that impact Earth's surface.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS2-3	**Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings and provide evidence for phenomena.	**The History of Planet Earth & Plate Tectonics and Large-Scale System Interactions:** Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches). Tectonic processes continually generate new ocean sea floor at ridges and destroy old seafloor at trenches. Standard Boundary includes paleomagnetic anomalies in oceanic and continental crust not being assessed.	**Pattern:** Explain that numerical relationships can provide information about systems.

Theories provide explanations in science based on evidence and laws are statements or descriptions of the relationships among observable phenomena. Both are well-supported with evidence and consensus of the scientific community.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS3-1	**Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.**	**Constructing Explanations and Designing Solutions:** Construct a scientific explanation based on reliable evidence from multiple sources (including the students' own experiments).	**Natural Resources:** Many resources are limited and not evenly available due to variations in the geography found on Earth. The focus should be on most resources being finite and cannot be easily replaced. Instruction should also include why resources such as petroleum and metal ores are found in larger amounts in certain areas. (burial of organic material, volcanic activity, hydrothermal activity).	**Cause and Effect:** Use cause and effect relationships to predict phenomena and systems.

W6.1: Write arguments to support claims with clear reasons and relevant evidence.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ESS3-2	**Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Natural Hazards:** Making connections between past history and natural forces can predict the possible time and location of future events. The focus should be on natural hazards that precede phenomena and can be used to predict a future event. Instruction should include events such as hurricanes, volcanic activity, tsunamis, and tornadoes. The data that is collected from each one of these events should also be used as evidence.	**Patterns:** Use graphs, charts, and images to identify patterns in data.

Iowans experience natural hazards (e.g. tornadoes, flooding and blizzards) and utilize various technologies to predict time and location of events.

Meteorologists work to keep us safe in dangerous weather. This includes local weatherpeople and national organizations like National Oceanic and Atmospheric Administration (NOAA).

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ETS1-1	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, considering relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ETS1-2	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**	**Engaging in Argument from Evidence:** Evaluate competing design solutions based on agreed-upon design criteria.	**Developing Possible Solutions:** There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ETS1-3	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Developing Possible Solutions & Optimizing the Design Solution:** Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies. Although technology is typically intended to solve problems, not all problems can be solved with technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
6-ETS1-4	**Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**	**Developing and Using Models:** Develop and/or use a model to generate data to test within a system, including representing inputs and outputs.	**Developing Possible Solutions & Optimizing the Design Solutions:** Models of all kinds are important for testing solutions. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Seventh Grade

Seventh grade students in Iowa explore the principles of forces, motion, energy, ecosystems and the solar system. In physical science, students investigate how forces impact the motion of objects, how energy transfers and transforms, and how to predict the outcomes of these interactions. They look at practical examples, like how friction affects speed or how energy changes in everyday scenarios. In life science, students learn about how plants and animals depend on each other and their environments to survive, examining ecosystems, food webs, and the role of biodiversity. In Earth and space science, they study Earth's place in the universe, including the solar system and how Earth's different systems (like water, air, and land) interact and shape our environment. Through these topics, students develop skills in observation, data analysis, and critical thinking, helping them connect scientific ideas to real-world situations.

The seventh-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- How do forces affect the motion of objects?
- How can we use evidence to predict future motion?
- How do the interactions between living organisms, their environments, and Earth's processes, such as the flow of energy and water, help sustain life on Earth?
- How do the motions of objects in our solar system, such as planets and moons, relate to the forces of gravity and the scale of these objects?
- How can we design and explain the workings of an energy-efficient amusement park ride?

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS2-1	**Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas or principles to design an object, tool, process or system.	**Forces and Motion:** Accurately describe Newton's Third Law of Motion, which states that when one object exerts a force on another object, the second object exerts a force back on the first that is equal in magnitude but opposite in direction. Standard Boundary is limited to vertical or horizontal interactions in one dimension.	**Systems and System Models:** Models are used to represent systems and interactions (e.g. inputs, processes, outputs) and the flow of information within the system.

The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Careers in Building Trades: Architecture, Construction and Engineering.

Theories provide explanations in science based on evidence and laws are statements or descriptions of the relationships among observable phenomena. Both are well-supported with evidence and consensus of the scientific community.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS2-2	**Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.**	**Planning and Carrying Out Investigations:** Plan an investigation that supports a claim. Include independent and dependent variables and controls, materials needed, processes for measurements and data recording.	**Forces and Motion:** An object's motion is determined by the net force acting on it; a larger force results in a greater change in motion, and heavier objects require more force to achieve the same change. Emphasis on balanced/unbalanced forces (Newton's 1st Law), qualitative force comparisons, mass and motion changes (Newton's 2nd Law), reference frames, and unit specification. Standard Boundary is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Standard Boundary does not include the use of trigonometry.	**Stability and Change:** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.

A pony truss bridge in Maxwell, IA is different from other truss bridges because it allows traffic to go through it and is not connected by braces over the top.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS2-3	**Construct an explanation using data to determine the factors that affect the strength of electric and magnetic forces.**	**Construct an Explanation:** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**Types of Interactions:** Electromagnetic forces can be attractive or repulsive, with strength depending on charge/current magnitudes and distance between objects. Devices utilizing electric and magnetic forces include electromagnets, electric motors, and generators; data could examine the impact of wire turns on electromagnet strength or magnet count/strength on motor speed. Standard Boundary about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.	**Cause and Effect:** Students can use cause and effect relationships to predict phenomena and systems.

Aurora borealis is visible in Iowa when conditions are favorable.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS2-4	**Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.**	**Engaging in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation, model, or solution for something you observe or a problem.	**Forces & Interactions:** Gravity is always attractive, and only becomes significant when objects have large masses, like the Earth and Sun. Evidence could include simulated data or charts showing mass, interaction strength, solar distance, and orbital periods of celestial bodies. Major human achievements in spaceflight, like the Apollo moon landings, and the exploration of the solar system with the Voyager space probes directly use precise measurements of planetary motion. Standard Boundary does not include Newton's Law of Gravitation or Kepler's Laws.	**Developing and Using Models:** Models are used to represent systems and interactions (e.g. inputs, processes, outputs) and the flow of information within the system.

Astronauts Peggy Whitson, Clayton Anderson, Raja Chari, Walter Cunningham, Laurel Clark, George Nelson, Dale Gardner, James Kelly, and Loren Shiver are all from Iowa. Iowa has strong ties with NASA through our Iowa Space Grant Consortium.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS2-5	**Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.**	**Planning and Carrying out an Investigation:** Conduct an investigation to gather data to see if your data matches the goal of the investigation; revise investigation design if needed.	**Forces & Interactions:** Electric and magnetic forces, acting at a distance, are explained by fields that permeate space and can be mapped using a test object like a charged particle or magnet. Examples include interactions between magnets, charged tape, and pith balls which can be investigated through direct observation or simulations. Examples of medical advances with magnets include MRIs, which use magnetic fields to see inside the body. Standard Boundary is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.	**Cause and Effect:** Students can use cause and effect relationships to predict phenomena and systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS3-1	**Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.**	**Analyze & Interpret Data:** Create and/or analyze graphs to identify linear or nonlinear relationships within the data.	**Energy:** Motion energy, or kinetic energy, is directly proportional to an object's mass and increases with the square of its speed. Focus on describing how kinetic energy relates to mass independently from its relationship with speed; examples of riding a bike at varying speeds and rolling different sizes of rocks downhill.	**Scale, Proportion, and Quantity:** The proportion is directly linked to the outcome of the process.

Car racing is very prominent in Iowa. Iowa Speedway in Newton holds NASCAR Cup and other races. There are also several race tracks that host drag racing including Cedar Falls, Earlville, Eddyville, and the I-29 Speedway. There are dozens of smaller dirt-car tracks around the state.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS3-2	**Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Definitions of Energy & Relationship Between Energy and Forces:** A system of objects may also contain stored (potential) energy, depending on their relative positions. Focus on comparing relative potential energy levels within systems, not precise calculations. Examples include a roller coaster cart at different heights on a hill, magnets changing orientation, or a charged balloon nearing hair, using visual models like diagrams and descriptions to illustrate. Standard Boundary is limited to two objects and electric, magnetic, and gravitational interactions.	**Systems and System Models:** Models are used to represent systems and interactions (e.g. inputs, processes, outputs) and the flow of information within the system.

Iowa has several amusement parks (i.e. Adventureland Park, Lost Island, Arnolds Park) to explore and explain stored potential energy.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS3-4	**Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.**	**Planning and Carrying Out Investigations:** Plan an investigation, identifying independent and dependent variables and controls, what tools are needed, and how measurements will be recorded.	**Definitions of Energy & Conservation of Energy and Energy Transfer:** Temperature reflects the average kinetic energy of matter particles, with the total system energy depending on the matter's type, state, and quantity. Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup. Standard Boundary does not include calculating the total amount of thermal energy transferred.	**Scale, Proportion, and Quantity:** The proportion is directly linked to the outcome of the process.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-PS3-5	**Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.**	**Engaging in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation, model, or solution for something you observe or a problem. Evaluate if the device, process, or system meets the important goals and limits.	**Conservation of Energy and Energy Transfer:** When the motion energy of an object changes, it results in a simultaneous change in another form of energy. For instance, empirical evidence of this energy transfer can be illustrated through temperature changes or the motion of the object, showing how energy is conserved before and after the transfer. Standard Boundary does not include calculations of energy.	**Energy & Matter:** Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS1-4	**Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.**	**Engaging in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation, model, or solution for something you observe or a problem. Evaluate if the device, process, or system meets the important goals and limits.	**Growth and Development of Organisms:** Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.	**Cause and Effect:** Phenomena may have more than one cause, and some relationships within a system can be described using probability.

Native flowers, crops, and pollinators are local to Iowa.

Careers in Agriculture, Food, and Natural Resources: (e.g., agronomists, fisheries and wildlife biologists).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS2-1	**Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings and provide evidence for phenomena.	**Interdependent Relationships in Ecosystems:** Organisms and populations depend on living and non-living factors. Those factors cause growth or declines in population based on availability of resources. In an ecosystem, organisms have to compete for resources which can affect their growth and reproduction. Growth of organisms and population increases are limited by access to resources.	**Cause and Effect:** Cause and effect relationships may be used to predict phenomena and systems.

Trojan Carp Project in the Missouri River involves reducing invasive species.

Careers in Agriculture, Food, and Natural Resources (e.g., agronomists, fisheries and wildlife biologists).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS2-2	**Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.**	**Constructing Explanations and Designing Solutions:** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**Interdependent Relationships in Ecosystems:** Predict the patterns of interactions in an ecosystem including, biotic/abiotic factors, symbiotic relationships, competition and predation. Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.	**Patterns:** Patterns can be used to identify cause and effect relationships.

Iowa has many keystone species like crawfish, oak trees, river otters, and freshwater mussels that affect ecosystems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS2-3	**Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.**	**Developing and Using Models:** Develop and/or revise a model to show the relationships among variables including those that are not observable but predict observable phenomena.	**Cycle of Matter and Energy Transfer in Ecosystems:** Food webs show how energy and materials move between three main groups: producers, consumers, and decomposers. These groups interact in an ecosystem to cycle energy and atoms between living and nonliving aspects of an ecosystem. Standard Boundary does not include the use of chemical reactions to describe the processes.	**Energy & Matter:** The transfer of energy can be tracked as energy flows through a designed or natural system.

Science assumes that objects and events in natural systems occur in consistent patterns that make sense through measurement and observation.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS2-4	**Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**	**Engaging in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation, model, or solution for something you observe or a problem. Evaluate if the device, process, or system meets the important goals and limits.	**Ecosystem Dynamics, Functioning, and Resilience:** Recognize patterns in data about changes in populations due to physical or biological disruptions in an ecosystem. Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.	**Stability and Change:** Small changes in one part of an ecosystem might cause large changes in another part.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-LS2-5	**Evaluate competing design solutions for maintaining biodiversity and ecosystem services.**	**Engaging in Argument from Evidence:** Evaluate competing design solutions to help maintain biodiversity and/or ecosystem services based on predetermined design criteria.	**Ecosystem Dynamics, Functioning, and Resilience:** Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.	**Stability and Change:** Small changes in one part of an ecosystem might cause large changes in another part.

The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.

Careers in Agriculture, Food, and Natural Resources (Department of Natural Resources, water treatment, and water lab chemists).

Iowa Living Roadways Community Visioning: Iowa Department of Transportation (DOT) program to plant Iowa native plants along roadways for prairie restoration.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ESS1-1	**Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**	**Developing and Using Models:** Develop and/or revise a model to show how the relative locations of the earth, sun, and moon allow us to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.	**The Universe and Its Stars & Earth and the Solar System:** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. Examples of models can be physical, graphical, or conceptual.	**Patterns:** Patterns can be used to identify cause and effect relationships.

Science assumes that objects and events in natural systems occur in consistent patterns that make sense through measurement and observation.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ESS1-2	**Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.**	**Developing and Using Models:** Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	**The Universe and its Stars & Earth and the Solar System:** The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. Students should model gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Standard Boundary does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.	**Systems and system models:** Models are used to represent systems and interactions (e.g. inputs, processes, outputs) and the flow of information within the system.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ESS1-3	**Analyze and interpret data to determine scale properties of objects in the solar system.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Earth and the Solar System:** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. Students should analyze data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the size of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings, photographs, and models. Standard Boundary does not include recalling facts about properties of the planets and other solar system bodies.	**Scale, proportion, and quantity:** Time, space, and energy can be studied using models to examine systems that are very large or very small.

Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. This includes Moon landings and sending probes to Mars and other solar system bodies.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ESS2-4	**Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.**	**Developing and Using Models:** Develop and/or revise a model to show the relationships between the sun's heat and gravity to help predict and/or explain how water moves through the hydrologic cycle.	**The Roles of Water in Earth's Surface Processes:** Global movements of water and its changes in form are propelled by the Sun's heat and gravity. Students should model (conceptually or physically) ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. Standard boundary does not include a quantitative understanding of the latent heats of vaporization and fusion is not assessed.	**Energy and Matter:** In a natural system, energy moves matter through cycles.

Waterfalls (Dunning's Springs State Park, Decorah, IA) and crop growth due to evapotranspiration.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ETS1-1	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, considering relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**	**Asking Questions and Defining Problems:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ETS1-2	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**	**Engaging in Argument from Evidence:** Evaluate competing design solutions based on agreed-upon design criteria.	**Developing Possible Solutions:** There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ETS1-3	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Developing Possible Solutions & Optimizing the Design Solutions:** Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies. Although technology is typically intended to solve problems, not all problems can be solved with technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
7-ETS1-4	**Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**	**Developing and Using Models:** Develop and/or use a model to generate data to test within a system, including representing inputs and outputs.	**Developing Possible Solutions & Optimizing the Design Solutions:** Models of all kinds are important for testing solutions. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Eighth Grade

Eighth grade students in Iowa explore how molecules form and change in reactions while conserving matter, analyze changes in substances to detect chemical reactions, and explore the roles of photosynthesis and metabolism in energy flow and growth in organisms. Students model genetic processes, examining how reproduction and mutations affect traits, and investigate relationships through fossil records, comparative anatomy, and embryology. They study natural selection's influence on population traits over time and how humans impact trait inheritance. Students learn to analyze trends in atmospheric patterns, understand synthetic materials' origins and societal impacts, and explore how population growth and resource use affect Earth’s systems. Through these standards, students develop a blend of scientific literacy and critical thinking, equipping them with the tools to make sense of and address complex, real-world issues.

The eighth-grade standards help students gather, analyze, and communicate evidence as they formulate answers to questions tailored to student interest and current topics that may include but are not limited to:

Examples of Grade-Level Driving Questions

- How do atoms combine, interact, and transform to create the world around us, and what evidence can we observe to make sense of these microscopic processes?
- How are the traits of a species passed along within a population due to their environment?
- How do our choices in creating and using materials affect our planet's health, and what evidence-based solutions can we develop to balance human needs with environmental sustainability?

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-PS1-1	**Develop models to describe the atomic composition of simple molecules and extended structures.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Structure and Properties of Matter:** Substances are made of different types of atoms that combine to form molecules, which can be simple or complex, ranging from two to thousands of atoms. Solids can be made of molecules or extended structures with repeating units, like crystals. Focus on creating models of molecules with varying complexity. Simple molecule examples include ammonia and methanol, while extended structures include sodium chloride and diamonds. Molecular-level models can be drawings, 3D ball-and-stick models, or computer representations showing different molecules with various types of atoms. Standard Boundary does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.	**Scale, Proportion, and Quantity:** Time, space, and energy can be studied using models to examine systems that are very large or very small.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-PS1-2	**Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Identifying Substances:** Each pure substance has specific physical and chemical properties that can be used for identification. Examples of reactions include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Standard Boundary is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.	**Scale, Proportion, and Quantity:** Phenomena that can be observed at one scale may not be observable at another scale.

Science knowledge is based upon logical and conceptual connections between evidence and explanations.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-PS1-3	**Construct an argument supported by evidence that synthetic materials come from natural resources and impact society.**	**Engaging in Argument from Evidence:** Make a written or spoken argument, using evidence and scientific reasoning, to support or challenge an explanation, model, or solution for something you observe or a problem. Evaluate if the device, process, or system meets the important goals and limits.	**Structure and Properties of Matter & Chemical Reactions:** Each pure substance has characteristic physical and chemical properties that can be used to identify it. Substances react chemically in specific ways. During a chemical process, the atoms of the original substances are rearranged into new molecules with different properties. Emphasize natural resources that undergo chemical processes to create synthetic materials, such as new medicines, foods, and alternative fuels. Standard Boundaries will focus on qualitative information only.	**Structure and Function:** Structures can be designed to serve particular functions by considering properties of different materials, and how materials can be shaped and used.

Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

RI.8.8: Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-PS1-5	**Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Chemical Reactions:** Substances react chemically in specific ways. During a chemical process, the atoms of the original substances are rearranged into new molecules with different properties. The total number of each type of atom is conserved, meaning mass stays the same. Focus on the law of conservation of matter using physical models or drawings, including digital representations, to illustrate atoms. Emphasize natural resources that undergo chemical processes to create synthetic materials, such as new medicines, foods, and alternative fuels. Standard Boundary will focus on qualitative information only and does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.	**Energy and Matter:** Matter is conserved because atoms are conserved in physical and chemical processes.

Theories provide explanations in science based on evidence and laws are statements or descriptions of the relationships among observable phenomena. Differentiating between laws and theories and how they are not hierarchical in their nature laws and theories are different types of scientific information. Both theories and laws are well-supported by evidence and the consensus of the scientific community.

In 2024 Iowa produced more fuel ethanol and biodiesel than any other state in the nation. (U.S. Energy Information Administration State Profile).

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS1-5	**Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.**	**Constructing Scientific Explanations:** Construct a scientific explanation based on reliable evidence from sources (including the students' own experiments) and the assumption that theories and laws about the natural world apply today as they did in the past.	**Growth and Development of Organisms:** Genetic factors as well as local conditions affect the growth of the adult plant. Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Standard Boundary does not include genetic mechanisms, gene regulation, or biochemical processes.	**Cause and Effect:** Use cause and effect relationships to predict phenomena which may have more than one cause, and some relationships within a system can be described using probability.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS1-6	**Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.**	**Constructing Scientific Explanations:** Construct a scientific explanation based on reliable evidence from sources (including the students' own experiments) and the assumption that theories and laws about the natural world apply today as they did in the past.	**Organization for Matter and Energy Flow in Organisms & Energy in Chemical Processes and Everyday Life:** Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. Standard Boundary does not include the biochemical mechanisms of photosynthesis.	**Energy & Matter:** Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Science knowledge is based upon logical connections between evidence and explanations.

RI.8.8: Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS1-7	**Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Organization for Matter and Energy Flow in Organisms & Energy in Chemical processes and Everyday Life:** Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. Standard Boundary does not include details of the chemical reactions for photosynthesis or respiration.	**Energy & Matter:** Matter is conserved in physical or chemical change.

Iowa's plants and animals require specific nutrients for growth and production.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS3-1	**Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Inheritance & Variation of Traits:** Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. In addition to variations that arise from reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. Standard Boundary does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.	**Structures and Systems:** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS3-2	**Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Inheritance of Traits:** Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. Traits are inherited from parents through chromosomes. We can predict the traits using Punnett squares, diagrams, and simulations to show how traits are passed from parents to offspring through genes.	**Cause and Effect:** Use cause and effect relationships to predict phenomena and systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-1	**Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Evidence of Common Ancestry and Diversity:** The fossil record establishes the patterns of where fossils are found (the rock layers) and the order they were found in (time periods). The fossil record documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns**: Use graphs, charts, and images to identify patterns in data.

Science knowledge is based upon logical and conceptual connections between evidence and explanations. Science assumes that objects and events in natural systems occur in consistent patterns that make sense through measurement and observation.

Iowa Department of Natural Resources (DNR) has many career opportunities related to the ecology and population of species in Iowa.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-2	**Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer relationships.**	**Constructing Explanations and Designing Solutions:** Apply scientific principles to create and/or test an object, tool, process, or system.	**Evidence of Common Ancestry and Diversity:** Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.	**Patterns:** Use patterns to identify cause and effect relationships.

RI.8.8: Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-3	**Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.**	**Analyzing and Interpreting Data:** Create and/or analyze graphs to identify linear or nonlinear relationships within the data.	**Evidence of Common Ancestry and Diversity:** Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. Standard Boundary of comparisons is limited to gross appearance of anatomical structures in embryological development.	**Patterns:** Use graphs, charts, and images to identify patterns in data.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-4	**Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.**	**Constructing Scientific Explanations:** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**Natural Selection:** Natural selection leads to the predominance of certain traits in a population, and the suppression of others. Emphasis is on using simple probability statements and proportional reasoning to construct explanations.	**Causes and Effect:** Phenomena may have more than one cause, and some relationships within a system can be described using probability.

RI.8.8:Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-5	**Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.**	**Obtaining, Evaluating, and Communicating Information:** Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**Natural Selection:** In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring.	**Cause and Effect:** Use cause and effect to make sense of phenomena that may have more than one cause. Some relationships within a system can be described using probability.

Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

There are several careers in Iowa that require skills with selective breeding for agricultural purposes.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-LS4-6	**Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.**	**Using Mathematics and Computational Thinking:** Use mathematical representations and concepts to figure out scientific and engineering questions and problems.	**Adaptations:** Species change over different generations through adapting to changes in their environment. If a species adapts, they display traits that make survival and reproduction more common to support the species continuing. Those that do not adapt do not develop the traits for survival and reproduction, making those species less common, resulting in population changes. Standard Boundary does not include Hardy Weinberg calculations.	**Cause and Effect:** Use cause and effect to make sense of phenomena that may have more than one cause. Some relationships within a system can be described using probability.

SMP 5: Use appropriate tools strategically: Graphs are charts are mathematical representations of how natural selection may increase or decrease populations over time.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ESS2-5	**Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.**	**Planning and Carrying Out Investigations:** Collect and communicate data to answer scientific questions.	**The Role of Water in Earth's Surface Processes & Weather and Climate:** The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. Because these patterns are so complex, weather can only be predicted probabilistically. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments. Emphasis is on how air masses flow, causing weather at a fixed location to change over time, and how sudden changes in weather can happen. Standard Boundary does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.	**Cause and Effect:** Use cause and effect relationships to predict phenomena and systems.

Careers in Meteorology could include weatherpersons, research scientists, and weather consultation experts.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ESS2-6	**Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.**	**Developing and Using Models:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**The Roles of Water in Earth's Processes & Weather and Climate:** Variations in density caused by variations in temperature and salinity create consistent ocean currents. Models and diagrams can be used to show how patterns vary by latitude, altitude, and geographic land distribution. Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all which can affect oceanic and atmospheric flow patterns. The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is impacted by the Coriolis effect. Standard Boundary does not include the dynamics of the Coriolis effect.	**Systems and System Models:** Models are used to represent systems and interactions (e.g. inputs, processes, outputs) and the flow of information within the system.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ESS3-3	**Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.**	**Constructing Scientific Explanations:** Apply scientific principles to design an object, tool, process or system.	**Human and Environmental Impacts on Earth Systems:** Impact on Earth systems is directly linked to the change in environments and/or extinction of a particular species. Changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect:** Identify relationships that can be classified as causal or correlational, and correlation does not necessarily imply causation.

The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time. New technologies can have deep impacts on society and the environment, including some that were not anticipated.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ESS3-4	**Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.**	**Engaging in Argument from Evidence:** Construct, use, and/or present an oral or written argument, supported by empirical evidence and scientific reasoning, to support or refute an explanation, model, or solution for a phenomenon, problem, or the advertised performance of a device, process, or system. Evaluate whether the technology meets relevant criteria and constraints.	**Human and Environmental Impacts on Earth Systems:** There is a direct correlation between the increased use of resources and the impact on Earth, unless there is a specific intent for new technology to be developed otherwise. The focus should be on human population growth and the correlation of the use of natural resources. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. Examples of evidence include data on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change.	**Cause and Effect:** Use cause and effect relationships to predict phenomena and systems.

Human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Agriculture is affected by changes in climate, including shifts in growing seasons, increased frequency of extreme weather events, and rainfall variability.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ESS3-5	**Ask questions to clarify evidence of the factors that have caused the change in global temperatures over time.**	**Asking Questions and Defining Problems:** Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	**Global Climate Changes and Trends:** The use of natural resources can be connected to changes in Earth's surface temperature. Data that show change in climate over time should be used. Examples of evidence could include tables, graphs, and maps of global and regional temperatures, or atmospheric levels of gases. The Earth has experienced natural warming and cooling throughout history such as during the Ice Age.	**Stability and Change:** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ETS1-1	**Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, considering relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**	**Asking Questions and Defining Problems:** Develop and/or use a model to predict and/or describe phenomena and unobservable features.	**Defining and Delimiting Engineering Problems:** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ETS1-2	**Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**	**Engaging in Argument from Evidence:** Evaluate competing design solutions based on agreed-upon design criteria.	**Developing Possible Solutions:** There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ETS1-3	**Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	**Developing Possible Solutions & Optimizing the Design Solutions:** Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies. Although technology is typically intended to solve problems, not all problems can be solved with technology.

Standard Code	Iowa Academic Standard in Science	Engineering Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
8-ETS1-4	**Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**	**Developing and Using Models:** Develop and/or use a model to generate data to test within a system, including representing inputs and outputs.	**Developing Possible Solutions & Optimizing the Design Solutions:** Models of all kinds are important for testing solutions. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. A solution needs to be tested, and then modified on the basis of the test results, in order to improve it.	NA

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

High School

High School Expectations Build Over Time

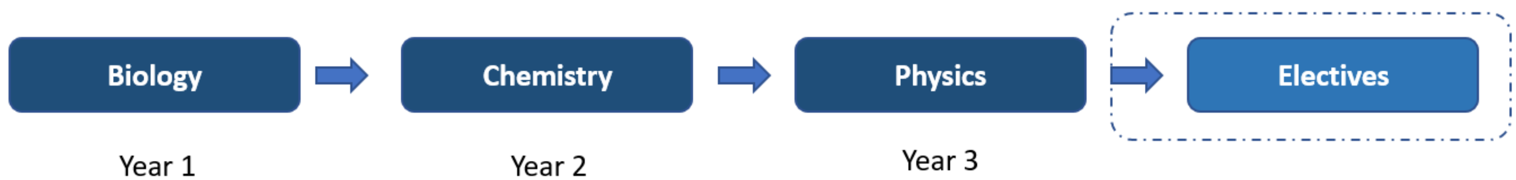
The expectations outlined in the high school standards are intended for the end of the high school grade band. Students are likely to encounter the disciplinary content only once during their high school journey, as these standards are integrated into the district's three-course sequence. However, the associated practices and conceptual frameworks will be engaged continuously throughout their high school experience. Given that these standards represent end-of-grade-band expectations, it may be unrealistic to expect students to meet this level of rigor at the beginning or middle of their high school studies. To assist educators in establishing appropriate rigor for practices and crosscutting concepts taught and assessed at earlier grade levels, Appendices A (science and engineering practices) and B (crosscutting concepts) have been created for clarification.

Model High School Course Pathways

The flexibility of high school science course sequences, which encompass both required and elective classes, poses a challenge in ensuring that all students are adequately prepared to meet all standards. Model course maps for grades 9–12 are designed around three core years, striving to balance the need for "**all standards, all students**" with the practical constraints of limited instructional time. Students, especially those interested in pursuing careers in science, technology, engineering, and mathematics (STEM), are strongly encouraged to take additional STEM courses to further enrich their preparation.

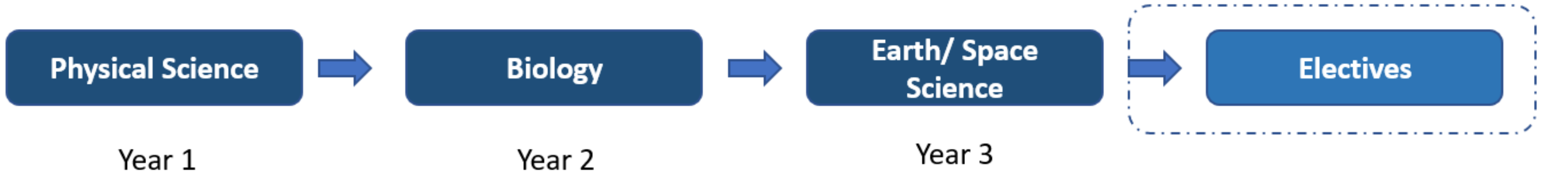
The following examples of high school course sequences are examples of how all of the standards **could** be placed in a three-course sequence guaranteeing that all students engage with all of the required science standards. Districts should choose a sequence that ensures that all students engage with all of the science standards in a way that fits with their district goals and logistics.

Example 1: Integrated Earth and Space Science Standards



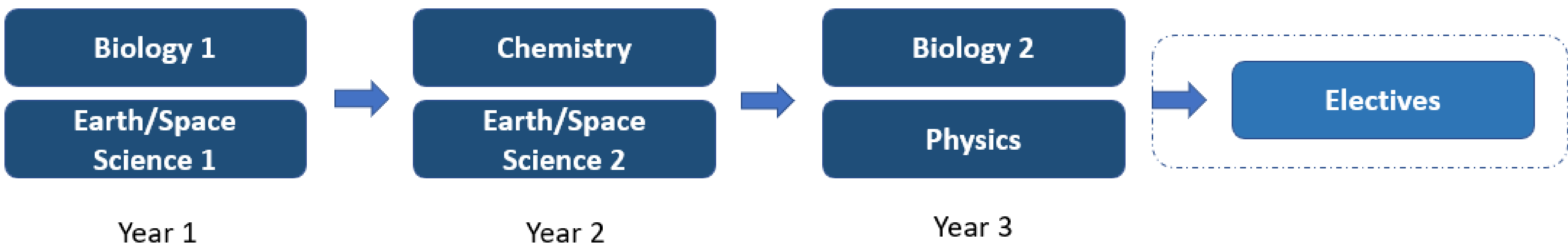
This model requires that the Earth and space standards be placed in the three required courses of Biology, Chemistry, and Physics. This model is ideal for students looking to attend college as some colleges require Biology as a requirement for admission. Many programs have specific other requirements, like regents nursing programs which require a year of high school physics for admission. This course sequence allows for easy adaptation for honors courses that may lead into AP or IB electives. Honors Physics, if done well, could be used as a replacement for AP Physics I, allowing students to enter the AP electives earlier.

Example 2: Combined Chemistry and Physics Course



This model moves the Physics and Chemistry standards into a Physical Science course taught in the first year. This course could be switched with the Biology course and taught second if a district has concerns with freshman mathematics abilities. Moving Physical Science before Biology introduces students to Chemistry content before they encounter some of the biological concepts like photosynthesis, respiration, and genetics, which require some sensemaking of chemical reactions. This sequence recognizes that the concepts in Earth and Space Science are applications of the fundamental principles from Physics, Chemistry, and Biology. This course sequence requires that electives in Physics and Chemistry be offered for students who desire to prepare themselves for college admission and success.

Example 3: Semester Long Courses



This model teaches each of these offerings as semester-length courses instead of full-year courses. Placing standards in this sequence moves the high school experience towards a more integrated approach in each grade level. The freshman Biology course may include standards in ecology and ecosystems, saving topics like genetics for the third year so that students can have experienced chemistry topics prior to making sense of complicated genetic phenomena. This sequence provides specific courses in Earth and Space Science and Physics. The environmental science course contains Life Science and Earth and Space Science standards that deal with human impact on our environment. By pulling out these standards, this model allows for Chemistry and Physics courses that are solely devoted to their content. This course sequence requires that a second semester elective in Physics and Chemistry be offered for students who desire to prepare themselves for college admission and success.

Career Pathways

After completing the required course sequence that meets state standards for graduation, students can further explore their science interests through elective courses. The table below presents various science-related career pathways, along with suggested science electives and relevant coursework in other subjects that may be beneficial for students pursuing these careers. Note that not all districts offer these electives so students will need to explore their district's offerings.

	Engineering	Medicine	Energy	Agriculture	Ecology	Meteorology
Sample Careers	Mechanical Electrical Civil Biomedical Computer Science Aerospace Systems	Doctor Nurse Surgeon Genetic Counseling Veterinarian Forensic Scientist	Geoscientist Nuclear Engineer Chemical Engineer	Farmer Animal Scientist Agronomist Food Scientist Botanist	Conservationist Naturalists Environmental Eng. Wildlife Biologist Marine Biologist Animal Scientist	Meteorologist Weather Scientist Climate Scientists
Science Courses	Physics Chemistry AP Physics I AP Physics II AP Physics C: Mechanics AP Physics C: Electricity and Magnetism Calculus IB Physics Astronomy Space Science Aerospace	Biology Chemistry Anatomy and Physiology AP Biology IB Biology Genetics Microbiology Forensics Physics AP Chemistry IB Chemistry Organic Chemistry	Earth Science Geology Energy and the Environment Organic Chemistry AP Chemistry IB Chemistry Principles of Technology	Biology Chemistry AP Biology IB Biology AP Chemistry IB Chemistry Organic Chemistry Zoology Botany Genetics	Biology Environmental Science AP Environmental Science IB Environmental Systems and Societies Marine Science Botany Zoology	Meteorology Physics AP Physics AP Chemistry
Non-Science Courses	Calculus CTE Engineering Pathway Computer Science	CTE CNA Pathway	Calculus Statistics Computer Science	CTE Agriculture pathway	Statistics	Calculus Computer Science

High School Physical Science Standards

Students at the high school level deepen their understanding of matter and its interactions by investigating more complex phenomena and constructing and defending more sophisticated models, arguments, explanations and designs. Relative to middle school, students' models, arguments, explanations, and designs should, for example, include more quantitative analysis, more clearly illustrate the connection between microscopic interactions and their macroscopic manifestations, and more explicitly acknowledge the tentative and iterative nature of models, arguments, explanations and designs.

As students investigate more complex phenomena and problems and develop more sophisticated sensemaking, Iowa students might explore questions such as:

- Why does the application of certain chemicals on roadways in winter make driving safer?
- How do safety features in cars protect passengers in a crash?
- What is the role of wind turbines in providing reliable electricity?
- What is the role of ethanol in using renewable energy resources?
- How can electromagnetic radiation be used to communicate over long distances?
- How can electromagnetic radiation be used to detect and treat disease?

As students explore these questions, they use one or more crosscutting concepts to better make sense of the problem/phenomenon under consideration, engage in practices as they participate in investigation and design, and deepen their understanding of science concepts that are required to more fully make sense of the problem and phenomena under consideration. In this way, high school students build on their previous learning in K-8 to build knowledge through active engagement in constructing and defending the models, arguments, and explanations/designs they produce in the high school science classroom.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.**	**Developing and using models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Structure and Properties of Matter:** Each atom consists of a positively charged nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. Standard Boundary is limited to main group elements, qualitative trends for ionization energy only.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Structure and Properties of Matter & Chemical Reactions:** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. Chemical reactions have predictable outcomes that are guided by the conservation of matter and the chemical properties of the atoms, ions or molecules involved. Standard Boundary is limited to reactions with main group elements & combustion.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

WHST.9-10.1a: Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.**	**Planning and Carrying out Investigations:** 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.	**Structure and Properties of Matter:** The structure and interactions of matter at the macroscale are determined by electrical forces within and between atoms. Macroscopic observations can be predicted by using kinetic molecular theory (including combined gas laws). Emphasis is on making sense of the strengths in the forces between particles, not on naming specific intermolecular forces. Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension. Standard Boundary does not include vapor pressure calculations.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

Brass tools are often used to reduce the chances of sparks being produced when working on metal pipes, whereas a steel hammer can produce unwanted sparks as indicated by MidAmerican Energy Des Moines Training Center for Excellence, Adel, Iowa. Iowa winters require various chemicals to be put on the roads to alleviate ice buildup.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Structure and Properties of Matter & Chemical Reactions:** The stability of matter is determined by energy states, where lower energy states are more stable than higher energy states. Bonds absorb energy to break and release energy when they form. Standard Boundary does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.	**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.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.**	**Constructing Explanations and Designing Solutions:** Apply reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning supports the claim.	**Chemical Reactions:** The rate of a chemical reaction is determined by the collision of the molecules/atoms and the rearrangement of those molecules/atoms that results in changes in energy. Standard Boundary is limited to observational evidence from temperature, concentration, and surface area changes in simple reactions with only two reactants.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

Iowa winters call for additives to be used in diesel vehicles.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.**	**Constructing Explanations and Designing Solutions:** Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	**Chemical Reactions & Optimizing the Design Solution:** The direction of a chemical process is dynamic and determined by the system conditions and the number and type of particles present in the system. Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products. Standard Boundary is limited to specifying the change in only one variable at a time AND does not include calculating equilibrium constants and concentrations.	**Stability and Change:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

Design a solution for a complex real-world problem by breaking down into smaller manageable steps.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**	**Use Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Chemical Reactions:** Chemical reactions have predictable outcomes that are guided by the conservation of matter and the chemical properties of the atoms, ions or molecules involved. Emphasis is on use of proportional relationships between masses of atoms in the reactants and the products and NOT on memorization & rote application of problem-solving techniques. Standard Boundary doesn't include complex chemical reactions.	**Energy and Matter:** The total amount of energy and matter in closed systems is conserved.

Science assumes the universe is a vast single system in which basic laws are consistent. Laws and theories are not hierarchical in their nature as they hold different types of scientific information.

SMP.2: Reason abstractly and quantitatively. MP.4: Model with mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS1-8	**Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Nuclear Processes:** Nuclear processes involve energy transfers and are explained by changes in sub atomic structures of the elements involved. The total number of neutrons plus protons does not change in any nuclear process but the identity of the atom may change. Standard Boundary is limited to alpha, beta, and gamma radioactive decays and does not include calculation of energy released.	**Energy and Matter:** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Clair Patterson born in Mitchellville, IA- work on lead isotopes and oceanic minerals to help calculate the age of the Earth.

Connections to Science and Technology in that different technologies available allowed evidence for the model to be refined over time. For example, absorption and emission spectra, x-ray diffraction, etc.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-1	**Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.**	**Analyzing and Interpreting Data:** Analyze data using provided tools, technology and/or a computational model to make a valid and reliable claim about a design solution.	**Forces and Motion:** Newton's second law predicts changes in the motion of macroscopic objects. Data examples include a position or velocity time graphs for an object undergoing a constant unbalanced force. Standard Boundary is limited to one dimensional motion of macroscopic objects moving at non-relativistic speeds.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Theories provide explanations in science based on evidence and laws are statements or descriptions of the relationships among observable phenomena.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-2	**Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.**	**Using Mathematics and Computational:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Forces and Motion:** Total momentum is conserved in any system. It is mass times the velocity of the object in a specific reference frame. Standard Boundary limited to 2 objects moving in 1 dimension, emphasizing the qualitative meaning of momentum conservation & the quantitative conservation.	**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.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics.

Momentum is a key principle used in developing three-staged rockets that helped Neil Armstrong, Buzz Aldrin and the rest of the Apollo astronauts get to the moon.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-3	**Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to solve design problems, considering possible unanticipated effects.	**Forces and Motion, Defining and Delimiting an Engineering Problem, & Optimizing the Design Solution:** Objects outside a system may interact with the system to change its total momentum; an equal change and opposite in momentum happens to the objects outside the system. Examples of evaluation and refinement could include determining the success of the device (such as a football helmet or a parachute) at protecting an object from damage, and modifying the design to improve it. Standard Boundary is limited to qualitative evaluations and/or algebraic manipulations.	**Cause and Effect:** Systems can be designed to cause a desired effect.

Analyze specific qualitative and quantitative criteria and constraints for a solution. Design a solution for a complex real-world problem by breaking down into smaller manageable steps.

Semi-trucks use aerodynamic fins to increase gas mileage.

Engineers create crumple zones to make cars safer for passengers and keep cars appealing to customers.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-4	**Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.**	**Using Mathematical & Computational Thinking:** Using mathematical representations includes graphical representations, proportional reasoning, and visual models (that show size of forces & the other variables). It can include but does NOT require formal calculations using the full laws.	**Types of Interactions:** Newton's law of universal gravitation and Coulomb's law provide data that describe and predict the effects of gravitational and electrostatic forces between objects of different masses. Standard Boundary is only between two object systems, emphasizing conceptual description of gravitational and electric fields and NOT on memorization & rote application of problem-solving techniques.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

Theories provide explanations in science while laws are statements or descriptions of the relationships among observable phenomena.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-5	**Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.**	**Planning and Carrying Out Investigations:** 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.	**Types of Interactions & Definitions of Energy:** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. This is assessed by designing & conducting investigations with provided materials. (Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.)	**Cause & Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS2-6	**Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.**	**Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information or ideas (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Types of Interactions:** Attraction/repulsion between atomic scale electric charges determine the macroscopic structure, properties, and function of matter, including contact forces between those objects. Standard Boundary is limited to molecular structures provided for specific designed materials.	**Structure and Function:** When investigating or designing new systems or structures, it's crucial to thoroughly examine the properties of various materials, the structures of different components, and how these components connect. This helps us make sense of their functions and find solutions to problems.

RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.**	**Using Mathematical & Computational Thinking:** Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.	**Definitions of Energy & Conservation of Energy and Energy Transfer:** Energy is a conserved quantity meaning the total energy transferred into, out of, or within systems must always be accounted for. In this sense, energy cannot be created or destroyed. The total energy for a closed system with internal transfers remains constant while systems that have an energy increase must be accompanied by a system(s) that have an equal decrease. States of systems or changes in states for systems can be predicted quantitatively with mathematical expressions based on measurable features of the system states. Standard Boundary is limited to basic algebraic expressions, tracking units, figuring percentages, or calculating quantities.	**Systems and System Models:** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Science assumes the universe is a vast single system in which basic laws are consistent.

A1. N-Q. A: Reason quantitatively and use units to solve problems.

Opening a compost pile on a chilly morning allows heat to escape and a thermometer stuck into a compost pile near the surface and deep into the pile, shows radically different temperatures on a spring day. In 2025, Iowa ranks in the top 10 for power grid reliability while maintaining some of the lowest electricity prices in the country for residential, commercial, and industrial customers (U.S. Energy Information Administration Annual Electric Power Industry Report, Oct 2025).

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS3-2	**Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Definitions of Energy:** At the microscopic scale, energy storage and transfer is accounted for through particle motion and particle interactions. In the absence of particles, energy storage is accounted for through gravitational, electric, or magnetic fields. Standard Boundary is limited to students representing their thinking about the storage and transfer of energy through the use of diagrams, graphs, charts, descriptions, algebraic expressions, and/or computer simulations.	**Energy and Matter:** Energy cannot be created or destroyed. Energy only moves between one place and another place, between objects and/or fields, or between systems.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS3-3	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.**	**Constructing Explanations and Designing Solutions:** Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	**Definitions of Energy & Energy in Chemical Processes & Defining and Delimiting an Engineering Problem:** Energy can be stored in a variety of ways; yet, can always be determined as the same quantity with the same units. (Energy can be stored gravitationally, nuclearly, radiantly, kinetically, thermally, chemically, elastically, electrically, and intermittently as sound or a wave.) Humans can guide the transfer of energy and attempt to make transfers as efficient as possible in an effort to optimize the desired changes in systems. Standard Boundary is limited to students representing their thinking about the storage and transfer of energy through the use of diagrams, graphs, charts, descriptions, algebraic expressions, and/or computer simulations.	**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.

Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Electrical energy from wind turbines must be transferred somewhere, it can't be stored efficiently. Therefore, when there is less demand, wind turbines are turned off. In 2025, Iowa ranks first in the nation for electricity produced by renewable energy per capita (U.S. Energy Information Administration State Profile).

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS3-4	**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).**	**Planning and Carrying Out Investigations:** 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.	**Conservation of Energy and Energy Transfer & Energy in Chemical Processes:** The second law of thermodynamics predicts thermal energy transfers occur in predictable patterns within closed systems. A system of substances or objects will progress towards thermal equilibrium associated with a greater dispersion of energy within the system. Standard Boundary is limited to students representing their thinking about the storage and transfer of energy through the use of diagrams, graphs, charts, descriptions, algebraic expressions, and/or computer simulations. For example, students can predict the final temperature of mixing a system of two different amounts of water at two different temperatures.	**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.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Relationship Between Energy and Forces:** Energy stored in a field is determined by the relative positions of objects in the system or their changes in position. Standard Boundary is limited to two object systems and qualitative representations of fields.	**Cause and Effect:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS4-1	**Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**	**Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Wave Properties:** Waves have measurable properties (wavelength, frequency, and speed) and are characterized by the mediums through which they can travel. Standard Boundary is limited to algebraic relationships and describing those relationships quantitatively.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Sundogs are colored spots of light that develop due to the refraction of light through ice crystals. The colored spots of light are seen around 22 degrees either to the left or right or on both sides of the sun.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS4-2	**Evaluate questions about the advantages of using a digital transmission and storage of information.**	**Asking Questions and Defining Problems:** Ask and evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.	**Wave Properties:** Electromagnetic wave pulses can effectively transmit digital information over long distances. Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.	**Stability and Change:** Systems can be designed for greater or lesser stability.

Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Information Technology is a growing field that handles the movement and storage of information.

Identification tags are used on cows. Radio frequency identification tags are used to track cattle and allow computers to gather real time data on the cow's movement, health and production.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.**	**Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Wave Properties & Electromagnetic Radiation:** Waves undergo both constructive and destructive interference. Electromagnetic radiation can be modeled as a wave (with changing electric and magnetic fields) or as particles called photons. Standards Boundary is qualitative descriptions only. Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Standard Boundary does not include using quantum theory.	**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.

A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of laws that have been repeatedly confirmed through observation and experiment. 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.

RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.**	**Obtaining, Evaluating, & Communicating Information:** Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.	**Electromagnetic Radiation:** Longer wavelengths can be absorbed in matter as thermal energy (heat). Shorter wavelengths ionize atoms which damage cells. Emphasis is on the connection between frequencies and energy of the EM radiation. Standard Boundary is limited to qualitative descriptions.	**Cause and Effect:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

There are several careers in the health sciences that use radiation to both image and affect matter including nurse, doctor, researchers, and technicians. This is most prevalent in cancer research.

RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-PS4-5	**Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.**	**Obtaining, Evaluating, & Communicating Information:** Communicate scientific and/or technical information or ideas (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Energy in Chemical Processes, Wave Properties, Electromagnetic Radiation & Information Technologies and Instrumentation:** Electrons can absorb light with high frequencies (such as solar cells). Applications of waves and their application with (matter such as medical imaging, radio signals, WIFI, communication devices) produce, capture, and transmit signals for storing and translating information. Standard Boundaries are limited to qualitative information and do not include band theory.	**Cause and Effect:** Systems can be designed to cause a desired effect.

Science and engineering complement each other in the cycle known as research and development (R&D). Modern civilization depends on major technological systems.

There are several careers in the health sciences that use radiation to both image and affect matter.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

High School Life Science Standards

Students at the high school level deepen their understanding of matter and its interactions by investigating more complex phenomena and constructing and defending more sophisticated models, arguments, explanations and designs. Students at the high school level should have a more complex understanding of living organisms and the cellular processes and scientific principles that guide them.

As students investigate more complex phenomena and problems and develop more sophisticated sensemaking, Iowa students might explore questions such as:

- How does the shape of a bald eagle's beak help it catch and eat fish in Iowa's rivers and lakes?
- Why do fish in Iowa streams have fins and gills, and how does this help them survive in fast-moving water?
- How do farmers in Iowa breed crops like corn so the plants grow with the same desired traits year after year?
- How does the presence of species like bees, butterflies, and songbirds benefit Iowa's prairies and farmland?

As students explore these questions, they use one or more crosscutting concepts to better make sense of the problem/phenomenon under consideration, engage in practices as they participate in investigation and design, and deepen their understanding of science concepts that are required to more fully make sense of the problem and phenomena under consideration. In this way, high school students build on their previous learning in K-8 to build knowledge through active engagement in constructing and defending the models, arguments, and explanations/designs they produce in the high school science classroom.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-1	**Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.**	**Constructing Explanations & Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Structure and Function:** All cells contain DNA. Regions within the DNA called genes code for the formation of specific proteins which help dictate the form and function of those cells. Systems of specialized cells within organisms help them perform the essential functions of life. Examples where DNA structure is important could include the use of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) as a medical innovation with numerous potential benefits in medicine, agriculture and biotechnology. Standard Boundary does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.	**Structure and Function:** When investigating or designing systems or structures, it's crucial to thoroughly examine the properties and structures of different components and how these components connect. This helps us make sense of their functions.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-2	**Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.**	**Developing & Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Structure and Function:** Multicellular organisms are organized in a hierarchical structure where one system is made up of numerous parts which work together to build the organism. Examples of interacting systems include nutrient uptake, water delivery, and movement in response to stimuli. Standard Boundary does not include interactions and functions at the molecular or chemical reaction level.	**Systems and Systems Models:** Models (e.g., physical, mathematical, computer, conceptual models) can be used to simulate systems and interaction within and between systems at different scales.

All careers in the Health Sciences career cluster depend on how systems of the body work together.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-3	**Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.**	**Planning & Carrying Out Investigations:** 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.	**Structure and Function:** Living systems strive to maintain stable internal conditions. Feedback mechanisms exist to help living things remain alive and functional even as external conditions change. Standard Boundary does not include the cellular processes involved in the feedback mechanism.	**Stability and Change of Systems:** Feedback (negative or positive) can stabilize or destabilize a system.

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.

WHST.9-10.7: 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.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-4	**Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.**	**Developing & Using Models:** Use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Growth and Development of Organisms:** Mitosis is a process in which the individual cells of multicellular organisms grow and divide, passing identical genetic information on to new daughter cells. Cellular growth and differentiation produce and maintain complex organisms composed of systems of tissues and organs that work together to meet the needs of the whole organism. Standard Boundary does not include specific gene control mechanisms or rote memorization of the steps of mitosis.	**Systems and System Models:** Models (e.g., physical, mathematical, computer, conceptual models) can be used to simulate systems and interactions within and between systems at different scales.

All careers in the Health Sciences career cluster depend on how systems of the body work together.

SMP.4: Model with Mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-5	**Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.**	**Developing & Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Organization for Matter and Energy Flow in Organisms:** The process of photosynthesis converts light energy to stored chemical energy. Inputs of matter to this system are carbon dioxide and water and outputs of matter from the system include sugars and oxygen. The process of photosynthesis involves a transfer and transformation of energy. Standard Boundary does not include specific biochemical steps.	**Energy and Matter:** Changes of energy and matter in a system can be described in terms of how energy and matter flows into, out of, and within that system.

Maple syrup is produced in Iowa by tapping trees.

Agriculture, Food, and Natural Resources career cluster such as farmer, agronomist, or botanist.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-6	**Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.**	**Constructing Explanations & Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Organization for Matter and Energy Flow in Organisms:** Living organisms are composed of complex molecules that contain carbon, hydrogen and oxygen backbones that originated from photosynthesis or through consumption of other living things. Standard Boundary does not include the details of the specific chemical reactions or identification of macromolecules.	**Energy and Matter:** Changes of energy and matter in a system can be described in terms of how energy and matter flows into, out of, and within that system.

All careers in the Health Sciences career cluster depend on how systems of the body work together.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS1-7	**Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.**	**Developing & Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Organization for Matter and Energy Flow in Organisms:** As matter and energy flow through organizational levels of living systems, chemical elements are recombined to form different products. 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. Standard Boundary should not include identification of the steps or specific processes involved in cellular respiration.	**Energy and Matter:** Energy cannot be created or destroyed. Energy only moves between one place and another place, between objects and/or fields, or between systems.

All careers in the Health Sciences career cluster depend on how systems of the body work together.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-1	**Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.**	**Using Mathematical & Computational Thinking:** Use mathematical and/or computational representations of phenomena to support explanations	**Interdependent Relationships in Ecosystems:** Ecosystems have limits (carrying capacities) which are influenced by resources, predation, competition, and disease. While organisms can produce large populations, environments have finite resources, which affects species abundance. Interdependent factors (resources, climate, and competition) impact population size. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. Standard Boundary does not include deriving mathematical equations to make comparisons.	**Scale, Proportion, and Quantity:** The significance of a phenomenon is affected by the scale, proportion, and quantity at which it occurs.

The Iowa Department of Natural Resources uses the idea of carrying capacity to manage the population of deer, fish, and other wildlife.

SMP.2: Reason abstractly and quantitatively

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-2	**Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.**	**Using Mathematical & Computational Thinking:** Use mathematical representations of phenomena or design solutions to support and revise explanations based on provided data.	**Interdependent Relationships in Ecosystems & Ecosystem Dynamics, Functioning, and Resilience:** A complex set of interactions within an ecosystem can keep its numbers and types of organisms (biodiversity) relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. Standard Boundary is limited to provided data.	**Scale, Proportion, and Quantity:** Scaled models can be compared and related together with varying orders of magnitude.

Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

Iowa bald eagle populations have changed over time as well as invasive species (e.g., ash borer disease, Asian beetles, zebra mussels).

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-3	**Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.**	**Constructing Explanations & Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Cycles of Matter and Energy Transfer in Ecosystems:** Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life. The focus is on making sense of the role of aerobic and anaerobic respiration in different environments, without assessing the specific chemical processes involved. Standard Boundary does not include the specific chemical processes of either aerobic or anaerobic respiration.	**Energy and Matter:** Energy drives the cycling of matter within and between systems.

Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.

Ethanol production is an example of a common Iowa product that relies on energy transfer during aerobic and anaerobic conditions for its production.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-4	**Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.**	**Using Mathematical & Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Cycles of Matter and Energy Transfer in Ecosystems:** Plants and algae form the base of the food web, and as energy and matter move up each level, only a small fraction is transferred to support growth and cellular respiration. This inefficiency results in fewer organisms at higher levels. Matter is cycled through food webs, and energy is conserved as it flows through ecosystems. Standard Boundary is limited to proportional reasoning to describe the cycling of matter and flow of energy.	**Energy and Matter:** Energy cannot be created or destroyed. Energy only moves between one place and another place, between objects and/or fields, or between systems.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-5	**Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.**	**Developing & Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Cycles of Matter and Energy Transfer in Ecosystems & Energy in Chemical Processes:** Photosynthesis and cellular respiration play key roles in the carbon cycle, where carbon moves between the biosphere, atmosphere, hydrosphere, and geosphere through various processes. Students will use models, such as simulations and mathematical representations, to make sense of this cycle. Standard Boundary does not include the specific chemical steps of photosynthesis and respiration.	**Systems and Systems Models:** Models (e.g., physical, mathematical, computer, conceptual models) can be used to simulate systems and interactions — including energy, matter, and information flows— within and between systems at different scales.

Prairie ecosystems were once the predominant land systems in Iowa that participated in the carbon cycle and built Iowa's rich soil.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-6	**Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.**	**Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Ecosystem Dynamics, Functioning, and Resilience:** Ecosystems have a complex set of interactions that help maintain a stable number and variety of organisms over time. If a small disturbance occurs, such as moderate hunting or a seasonal flood, the ecosystem can often return to its original state, showing resilience. However, extreme changes, like volcanic eruptions, loss of prairie habitat, or sea level rise, can disrupt resources and habitats.	**Stability and Change:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

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.

Loss of prairie habitat, habitat restoration, and impacts on species (example: pheasant populations, oak savannah, etc.) are all important topics in Iowa.

RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.

A2. S-IC.B.6: Evaluate reports based on data.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-7	**Design, evaluate, and refine a solution for increasing environmental sustainability and biodiversity.**	**Constructing Explanations & Designing Solutions:** Engineering: Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	**Ecosystem Dynamics, Functioning, and Resilience, Biodiversity and Humans & Developing Possible Solutions:** Humans depend on the living world for the resources and other benefits provided by biodiversity. Human activity can impact biodiversity in various ways, such as through population growth, introduction of invasive species, natural habitat destruction, pollution, and changes in climate. People around the world are increasingly developing innovative and sustainable solutions to protect and preserve our planet's rich biodiversity. Speciation increases balanced biodiversity. Sustaining biodiversity of a functioning ecosystem is essential to support and enhance life on Earth.	**Developing Possible Solutions:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

Agricultural practices, water quality, Iowa's alternative energy sources (biofuels, wind energy, etc.).

WHST.9-10: WHST.11-12.7: 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.

Engineers design, evaluate, and refine a solution to complex real-world problems.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS2-8	**Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**	**Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Social Interactions and Group Behavior:** Group behaviors evolved due to enhanced survival of individuals and their genetic relatives. Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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.

Migration of snow geese happens across Iowa each fall and spring.

RST.9-10.8: Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS3-1	**Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information.	**Structure and Function & Inheritance of Traits:** Each chromosome contains a long DNA molecule with genes as segments. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, leading to particular traits. Not all DNA codes for protein; some regulate functions or have unknown roles. Standard Boundary does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Livestock and crops are bred to have properties that make them more economical.

Agriculture, Food and Natural Resources; Health Sciences such as breeding cattle, or genetically modifying crops.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS3-2	**Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.**	**Engaging in Argument from Evidence:** Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student generated evidence.	**Variation of Traits:** In sexual reproduction, chromosomes can exchange sections during meiosis, creating new genetic combinations. Although DNA usually copies accurately, mistakes or environmental influences can lead to mutations, which add to genetic diversity. Environmental factors can also affect how inherited traits are expressed. This means that the traits we see in a population depend on both genetic factors and the environment. Standard Boundary does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Livestock and crops are bred to have properties that make them more economical.

Agricultural and environmental professionals collaborate to study and make recommendations for soil and water conservation.

WHST.9-10.1: Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS3-3	**Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.**	**Analyzing & Interpreting Data:** Use digital tools to apply concepts of statistics and probability to make data fit into slope, correlation, and intercept) to solve scientific and engineering questions and problems.	**Variation of Traits:** Environmental factors influence the probability of trait expression, affecting their occurrence in a population. Thus, both genetic and environmental factors determine the variation and probability of traits. Standard Boundary does not include Hardy-Weinberg calculations.	**Scale, Proportion, and Quantity:** Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).

Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.

G.S-CP: Use independence and conditional probability to interpret data.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-1	**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.**	**Obtaining, Evaluating, & Communicating Information:** Communicate scientific and/or technical information or ideas (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).	**Evidence of Common Ancestry and Diversity:** There are many types of evidence that support common ancestry and biological change over time. Genetic information gives important clues about how species have evolved. Although DNA sequences vary between species, the similarities reveal how different groups have branched out over time. By comparing DNA, protein sequences, anatomical structures, the fossil record, and patterns in embryo development, scientists can make sense of how species are related. Each of these types of evidence—like shared DNA, similar body parts, and development stages—helps us see how species evolved from common ancestors.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining 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. Scientific knowledge assumes that natural laws operate today as they did in the past and they will continue to do so in the future.

Devonian Fossil Gorge, Rockford Iowa Fossil and Prairie Park, Iowa Mastodon discoveries are all local Iowa resources.

RST.11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-2	**Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.**	**Constructing Explanations & Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Natural Selection & Adaptation:** Natural selection happens only when there is both (1) variation in the genetic information between organisms in a population (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. The process of natural selection results in the biological change of a species. Standard Boundary does not include other mechanisms of evolution, such as genetic drift, and gene flow through migration.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Avian influenza is something that the Department of Natural Resources (DNR) tracks.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-3	**Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.**	**Analyzing & Interpreting Data:** Use digital tools to apply concepts of statistics and probability to make data fit into slope, correlation, and intercept) to solve scientific and engineering questions and problems.	**Natural Selection & Adaptation:** Natural selection happens only when there is both (1) genetic variation within a population and (2) differences in how those genes are expressed as traits, leading to varied abilities among individuals. Traits that help with survival are more likely to be passed on to the next generation, gradually becoming more common in the population. Standard Boundary is limited to basic statistical and graphical analysis. Standard Boundary does not include allele frequency calculations.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

A2. S-ID: A Summarize, represent, and interpret data on a single count or measurement variable.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-4	**Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**	**Constructing Explanations & Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Adaptation:** Adaptation in a population happens through natural selection. Traits that help a species survive—such as physical features, behaviors, and body functions—are more likely to be passed down to future generations. These helpful traits are inherited by offspring, while traits that do not aid in survival tend to become less common over time. Examples of adaptation may include how bacteria become resistant to antibiotics requiring the development of new drugs. Standard Boundary is limited to basic statistical and graphical analysis of the data given.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Scientific knowledge assumes that natural laws operate today as they did in the past and they will continue to do so in the future.

Monarch butterfly populations move through Iowa on their migrations.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-5	**Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.**	**Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Adaptation:** Natural or human-driven changes to the physical environment can influence the expansion of species. These shifts may lead to the formation of distinct new species as populations diverge and adapt to altered environmental conditions. Extinction happens when species cannot survive and reproduce in altered environments. When change is too fast or drastic, species cannot evolve quickly enough and go extinct.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Clearing invasive species (example: musk thistle from prairies, carp) or the adaptation of native species (examples: prairie plants and prairie chickens).

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.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-LS4-6	**Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.**	**Using Mathematical & Computational Thinking** Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.	**Adaptation, Biodiversity and Humans & Developing Possible Solutions:** Natural or human induced physical environment changes can change species expansion. These changes can cause distinct new species as populations diverge due to changing environmental conditions. Sustainable ecosystems rely on balanced biodiversity to survive. Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

WHST.9-10.7: 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.

Create or revise a simulation of a phenomenon, designed device, process, or system.

New bee species, orchids, and fish are now found in Iowa.

High School Earth and Space Science Standards

Students at the high school level deepen their understanding of Earth and space by investigating more complex phenomena and constructing and defending more sophisticated models, arguments, explanations, and designs. Relative to middle school, students' models, arguments, explanations and designs should, for example, include more quantitative analysis, more clearly illustrate connections to the nature of science, identify relationships between science and Iowa industry, and more explicitly acknowledge the tentative and iterative nature of models, arguments, explanations and designs.

As students investigate more complex phenomena and problems and develop more sophisticated sensemaking, Iowa students might explore questions such as:

- Why do planets, stars, and falling objects move in predictable ways?
- Why do stars emit light?
- How do scientists use light to observe and explain objects in space? How does light pollution in populated areas, like Des Moines, affect our ability to observe space?
- What are some ways people in Iowa help protect natural areas, like wetlands, and why is this important?
- How does the way we use energy and resources locally and globally impact the climate on a larger scale?

As students explore these questions, they engage in practices as they participate in investigation and design and deepen their understanding of science concepts that are required to more fully make sense of the problem and phenomena under consideration. In this way, high school students build on their previous learning in K-8 to build knowledge through active engagement in constructing and defending the models, arguments, and explanations/designs they produce in the high school science classroom.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-1	**Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation, supplying Earth with energy.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**The Universe and Its Stars & Energy in Chemical Processes and Everyday Life:** Energy released by processes within the sun reaches the Earth through radiation. This radiation varies in cyclic and non-cyclic ways. Over time, the sun will deplete available resources and "burn out". Standard Boundary does not include details of the atomic and subatomic processes involved with the sun's nuclear fusion.	**Scale, Proportion, and Quantity:** The significance of a phenomenon is affected by the scale, proportion, and quantity at which it occurs.

While models have limitations, scientists use models to generate and test their ideas about the natural world.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-2	**Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**The Universe and Its Stars & Electromagnetic Radiation:** Radiation (visible and invisible light across the electromagnetic spectrum) are used to investigate stars and the universe. Observations from radiation provide evidence for an expanding universe (red shift), composition of stars, and the Big Bang theory. Nuclear fusion within stars produces all atomic nuclei heavier than helium and up to Iron. This fusion process releases electromagnetic energy. When very massive stars reach supernovae, elements heavier than Iron are produced, also through nuclear fusion.	**Energy and Matter:** Energy cannot be created or destroyed. Energy only moves between one place and another place, between objects and/or fields, or between systems.

Scientific theories and laws are distinct ways of making sense of the natural world. Both theories and laws are well-supported by empirical evidence and the consensus of the scientific community. Theories are explanations to account for a wide range of observations while laws are descriptions of patterns in nature. Both are limited in their scope and domain of applicability.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.**	**Obtaining, Evaluating, and Communicating Information:** Communicate scientific and/or technical information or ideas (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).	**The Universe and Its Stars:** Nuclear fusion within stars produces all atomic nuclei heavier than helium and up to Iron. This fusion process releases electromagnetic energy. When very massive stars reach supernovae, elements heavier than Iron are produced, also through nuclear fusion. Standard Boundary does not include details of the many different nucleosynthesis pathways for stars of different masses.	**Energy and Matter:** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-4	**Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.**	**Using Mathematical and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. Within this standard, mathematical and computational thinking may include algebraic expressions, graphs, simulations, and mathematical models.	**Earth and the Solar System:** Kepler's laws describe orbital motion of objects. Variations from predicted motion can be explained by additional gravitational or direct impact effects. General relativity provides an explanation for why objects orbit according to Kepler's laws. Standard Boundary does not include the use of calculus or situations that use more than two bodies.	**Scale, Proportion, and Quantity:** Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).

Science and engineering complement each other in the cycle known as research and development (R&D). Modern civilization depends on major technological systems.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with Mathematics.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-5	**Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.**	**Constructing Explanations and Designing Solutions:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**The History of Planet Earth, Plate Tectonics and Large-Scale System Interactions & Nuclear Processes:** The Earth's crust has dynamic differences in age, depth, and density due to the creative and destructive nature of tectonic plate interactions. Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).	**Patterns:** Empirical evidence is needed to identify patterns.

Plate tectonic theory is one of the more recent scientific revolutions in modern history.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS1-6	**Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.**	**Constructing Explanations and Designing Solutions:** Apply reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning supports the claim.	**The History of Planet Earth & Nuclear Processes:** Analysis of celestial bodies within our solar system and observation of the Earth's cratering record reveals information about the Earth's formation and early history. Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system billions of years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces. The Earth is continually changing today due to processes like plate tectonics and erosion which has led to the destruction of the Earth's early rock records.	**Stability and Change:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

Scientific theories and laws are distinct ways of making sense of the natural world. Both theories and laws are well-supported by empirical evidence and the consensus of the scientific community. Theories are explanations to account for a wide range of observations while laws are descriptions of patterns in nature. Both are limited in their scope and domain of applicability.

Manson impact crater is an example of how meteorites have shaped Iowa's landscape.

WHST.9-10.2: WHST.11-12.2: Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-1	**Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean floor features.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Earth Materials and Systems & Plate Tectonics and Large-Scale System Interactions:** The changing Earth is a result of the cyclical nature of plate tectonics, human behavior, and climate trends. As a result, the Earth's crust continually experiences construction and destruction via the movement of plate tectonics, melting of glaciers due to temperature rise, increased soil erosion due to vegetation loss, higher levels of local humidity due to wetland loss, and changes in erosion patterns due to dams. Plate tectonics explains how rocks at Earth's surface have moved in the past and continue to move today. This theory is used to make sense of geologic history. This standard emphasizes internal processes and the impact on Earth's surface. Standard Boundary does not include memorization of the details of the formation of specific geographic features of Earth's surface.	**Stability and Change:** Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.

While models have limitations, scientists use models to generate and test their ideas about the natural world. Plate tectonic theory is an example of a scientific revolution in modern history. This episode illustrates the complex interplay between ideas, evidence, and expertise. While Alfred Wegener was able to articulate sufficient evidence for "continental drift", his lack of a detailed mechanism prevented his peers from accepting his ideas until the theory of plate tectonics was accepted.

The role of glaciers in forming Iowa's landscape and the interaction of glacier activity and wind in formation of the Loess Hills.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-2	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.**	**Analyzing and Interpreting Data:** Analyze data using provided tools, technology and/or a computational model to make a valid and reliable claim about a design solution.	**Earth Materials and Systems & Weather and Climate:** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. This standard emphasizes surface processes, the resulting change, and feedback loops. Standard Boundary does not include memorization of the details of the formation of specific geographic features of Earth's surface.	**Stability and Change:** Feedback (negative or positive) can stabilize or destabilize a system.

Modern civilization depends on major technological systems. New technologies can have deep impacts on society and the environment, including some that were not anticipated.

Agricultural and environmental professionals collaborate to study and make recommendations for soil and water conservation.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-3	**Develop a model based on evidence of Earth's interior to describe and explain the cycling of matter by thermal convection.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Earth Materials and Systems & Plate Tectonics and Large-Scale System Interactions:** Models of the Earth have been informed by analysis of seismic waves, evaluation of changes to the Earth's magnetic field, observations of deep probes into the Earth's crust, reconstructions of the Earth's historical surface changes, and the application of physical and chemical processes. These models include a hot, solid inner core, a liquid outer core, a predominantly solid mantle, and the crust. Convection currents, which occur due to the changing density of the upper mantle as it heats and cools, drive plate movement. The convection cycles in the mantle that drive plate tectonics are powered from the energy generated by the radioactive decay of elements in Earth's core. We know this from seismic wave data, changes to Earth's magnetic field, and laboratory experiments. Each of Earth's layers are composed of different materials that determine their densities resulting in the densest layer in the middle and least dense on the surface.	**Energy and Matter:** Energy drives the cycling of matter like magma within and between systems.

Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory. Plate tectonic theory is an example of a scientific revolution in modern history.

Science and engineering complement each other in the cycle known as research and development (R&D). Modern civilization depends on major technological systems.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-4	**Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in climate changes and trends.**	**Developing and Using Models:** Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.	**Earth and the Solar System, Earth Materials and System & Weather and Climate:** Changes to the Earth's regional and global climate occur on varied time frames from sudden to long-term and in between. Geological records attribute these changes to multiple factors including changes in the sun's energy output, shifts in the Earth's orbit, tectonic events and volcanic activity, ocean circulation, glacier changes, consumption of natural resources, and vegetation distributions. These changes are observed via shifts in surface temperature, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution. Earth's climate is ultimately powered by electromagnetic radiation from the sun. Once the energy reaches Earth it can be reflected, absorbed, stored, or redistributed among the atmosphere, ocean, and land and eventually re-radiated into space. Earth's climate can change on a short or long-term scale. Examples of the causes of climate trends differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition. These changes are observed via shifts in surface temperature, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution. Standard Boundary is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Related Iowa careers and industry include biofuels, wind, solar and hydroelectric energy production.

Manufacturing, Technology, Engineering such as environmental engineering.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-5	**Plan and conduct an investigation of the properties of fluids (i.e. wind and water) and their effects on Earth materials and surface processes.**	**Planning and Carrying Out Investigations:** 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.	**The Roles of Fluids in Earth's Surface Processes:** Without liquid water, Earth's surface would not look the way it does. Water has the ability to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting points of rocks. Similarly, air masses experience changes in density, temperature, and motion resulting in wind which impacts the earth's surface. The properties of fluids are easily demonstrated in a laboratory setting to show the importance of fluids to the rock cycle. Examples of potential investigations include but are not limited to stream transportation and deposition using a stream table, wind investigations with fans, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes, solubility testing of different materials in water, or testing the melt temperatures of different compounds with and without water present.	**Structure and Function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Wind and water both impact agriculture through soil erosion, nutrient interaction, and runoff. This erosion and runoff have implications for water quality throughout the state.

Agricultural and environmental professionals collaborate to study and make recommendations for soil and water conservation.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-6	**Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Weather and Climate:** The composition of the atmosphere can change gradually over time due to plants and other photosynthetic organisms capturing carbon dioxide and releasing oxygen. These changes can be demonstrated in feedback loops between the biosphere (including humans), geosphere, hydrosphere, and atmosphere. Evidence of these feedback loops can be seen throughout Earth's history with the relationship of oxygen production, soil development, weathering patterns, and the biological change over time of organisms. Changes in the atmosphere from human activity have increased carbon dioxide concentrations and affected Earth's climate. Standard Boundary does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.	**Energy and Matter:** The total amount of energy and matter in closed systems is conserved.

SMP.2: Reason abstractly and quantitatively. SMP.4: Model with Mathematics

Agriculture leverages the connections among the hydrosphere, atmosphere, geosphere, and biosphere to improve agricultural processes (e.g., food, fuel, and fiber production).

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS2-7	**Construct an argument based on evidence about the simultaneous coevolution in Earth's systems and life on Earth.**	**Engaging in Argument from Evidence:** Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.	**Weather and Climate & Biogeology:** Feedback loops between the biosphere and Earth systems cause change of Earth's surface and the life that exists on it. An example of this change could include the formation of coral reefs changing patterns of erosion and deposition along coastlines which created habitats for new life forms. Standard Boundary does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.	**Stability and Change:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

WHST.9-10.1a: Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and climate changes and trends have influenced human civilizations.**	**Constructing Explanations and Designing Solution:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Natural Resources & Natural Hazards:** Resource availability such as fresh water, fertile soil, and high concentrations of minerals have impacted the development of human society. Natural hazards (e.g., flooding, tornadoes, earthquakes, etc.) and geological events (e.g., mineral deposits, fossils, fertile soils, etc.) have shaped the course of human history leading to population development and migration.	**Cause and Effect:** Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Modern civilization depends on major technological systems. Society and technology interact in both positive and negative ways depending upon various perspectives. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choices impact technology.

Examples of Iowa natural resources include: soil, water, grain crops, livestock, and natural areas. Examples of Iowa natural hazards include: tornadoes, flooding, derechos, blizzards, droughts, and extreme cold and heat.

WHST.9-10.1a: Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.**	**Engaging in Argument from Evidence:** Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	**Natural Resources & Developing Possible Solutions:** Energy production and resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. Examples may include best practices for agriculture soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas) with a focus on conservation, recycling, and reuse of materials where possible and minimizing global impact. New technologies and social regulations can change the balance in these factors.	NA

Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. 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. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Engineers continuously modify technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology.

Related Iowa industries include biofuels, wind, solar and hydroelectric energy production and mining industries such as limestone and sand.

Careers in construction, engineering, and city planning must account for unpredictable weather due to regional and global climate trends.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-3	**Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.**	**Using Mathematics and Computational Thinking:** Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.	**Human and Environmental Impacts on Earth Systems:** The sustainability of human societies and biodiversity that supports them requires management of natural resources (e.g., new technology, agricultural efficiency, urban planning, and cost benefit analysis). Standard Boundary for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.	**Stability and Change:** Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.

Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choices impact technology.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-4	**Evaluate or refine a technological solution that reduces society's influence on natural systems.**	**Constructing Explanations and Designing Solutions:** Engineering: Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions	**Impacts on Earth Systems & Developing Possible Solutions:** Scientists, engineers, and cities can make major contributions by collecting data (e.g., species diversity and pollution survey) and developing technologies and local efforts that produce less waste and reduce ecosystem degradation. 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. Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions.	**Stability and Change:** Feedback (negative or positive) can stabilize or destabilize a system.

Iowa connections include the use of wind turbines and biofuels and the use of prairie, buffer strips, cover crops, and riparian areas to reduce impact on the environment.

Many careers (e.g., construction, agriculture, transportation) use modern technologies such as GPS, drones, and automation to increase efficiencies to reduce impacts.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-5	**Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate changes and trends and associated future impacts to Earth systems.**	**Analyze and Interpreting Data:** Analyze data using provided tools, technology and/or a computational model to make a valid and reliable claim about a design solution.	**Global Climate Changes and Trends:** Though scientific evidence supports society's influence on the Earth and climate (e.g., precipitation and temperature data), scientist's ability to model, predict, and manage current and future impacts is improving (e.g., sea level, glacial ice volumes, flood management, erosion mitigation, etc.).	**Stability and Change:** Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.

Science investigations use diverse methods and do not always use the same set of procedures to obtain data. That is, there is no single step-by-step "scientific method". New technologies advance scientific knowledge. Science knowledge is based on empirical evidence. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Careers in construction, engineering, and city planning must account for unpredictable weather due to regional and global climate trends.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Science Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified over time.**	**Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Weather and Climate & Global Climate Changes and Trends:** Through computer simulations and other studies, important discoveries are still being made about how the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere interact (e.g., rainfall in large amounts increases soil run-off, which impacts large bodies of water including the Gulf of Mexico's Dead Zone). Current models predict that, although future regional climate changes and trends will be complex and varied, average global temperatures may continue to rise with a range of possible environmental changes. Standard Boundary does not include running computational representations but is limited to using the published results of scientific computational models.	**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.

All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

MP.2: Reason abstractly and quantitatively. MP.4: Model with mathematics.

High School Engineering, Technology, and Society Standards

The Iowa Academic Standards for Science demonstrate a commitment to incorporating engineering design into science education. There are both practical and visionary reasons for this inclusion. Providing students with a foundation in engineering design empowers them to engage with, and ultimately address, the complex societal and environmental challenges they will encounter in the future. The standards reflect this by embedding engineering design throughout the document in two key ways.

This integration recognizes the interactions of technology and society and raises questions about the trade-offs and values embedded within technological artifacts and systems. Because technology influences thinking and behavior, technology impacts individuals and society. Yet, through individual and collective choices, society impacts technology. Although all technologies come with trade-offs, identifying these tradeoffs can improve the design and use of the technologies. Despite designers' intent to solve problems, not all problems can be solved with technology.

Questions students might wrestle with include:

- What physical, temporal, and cultural constraints impact engineering and technological design?
- In what ways do modern technologies both disrupt and maintain social structures?
- How do technological artifacts and/or systems impact individuals and society?
- How do multiple competing solutions compare for solving particular problems?

It's important to note that while the Iowa Academic Standards for Science do not provide a comprehensive set of engineering, technology, and society standards, they do include essential concepts necessary for students to be scientifically literate citizens. Engineering design should not be taught in isolation but should be integrated within the context of disciplinary science content. The engineering, technology, and society standards (ETS) are not meant to stand alone; rather, they are intended to be woven into science courses, units, and lessons, reinforcing the connections between scientific concepts, engineering practices, technology, and society.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.**	**Asking Questions and Defining Problems:** Define a design problem that involves the development of a process or system with interacting components, criteria and addresses constraints that include social, technical and/or environmental considerations.	**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. 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.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ETS1-2	**Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**	**Constructing Explanations and Designing Solutions:** Design, a solution to solve a problem while considering unintended consequences of possible solutions.	**Optimizing the Design Solution:** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ETS1-3	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.**	**Constructing Explanations and Designing Solutions:** Evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	**Developing Possible Solutions:** When evaluating solutions, it is important to consider a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	NA

New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. Because technology influences how people think and act, technology impacts society. Yet, people and society, through their individual and collective choice, impact technology. All technologies come with trade-offs. When identified, these tradeoffs can improve the design and use of the technologies. Although technology is typically intended to solve problems, not all problems can be solved with technology.’

Standard Code	Iowa Academic Standard in Science	End of Grade Band Engineering Practice Clarification	Disciplinary Core Idea Clarification	End of Grade Band Crosscutting Concept Clarification
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**	**Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of design solutions to describe and/or support claims and/or explanations.	**Developing Possible Solutions:** Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**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.

Technologies are designed with a particular purpose; these embedded values influence how technology is used.

Appendix A- Scaffolded High School Practice Clarifications

Asking Questions and Defining Problems

Beginning	Middle	End
Ask questions to seek clarification of observations related to a provided phenomenon.	Ask questions to make sense of and clarify unexpected results during an investigation of a phenomena.	Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information.
Ask questions related to a provided model or theory to gain greater understanding.	Ask questions that arise from examining models or theory to either clarify or seek additional information and relationships.	Ask questions that arise from examining models or a theory, to clarify and seek additional information and relationships.
Ask questions to determine relationships between variables.	Ask questions to determine relationships between independent and dependent variables.	Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
Ask questions to clarify a model, explanation, or an engineering problem.	Ask questions to refine a model, an explanation, or an engineering problem.	Ask questions to clarify and refine a model, an explanation, or an engineering problem.
Evaluate if a question is relevant to understanding a phenomenon.	Evaluate if a question is testable in order to investigate a phenomenon.	Evaluate if a question is relevant and testable for a phenomenon.
Ask questions that are testable within the constraints provided by a teacher in a school environment.	Ask questions that are testable within the constraints of a school environment and develop a hypothesis.	Ask questions that are testable within the constraints of a school environment, research facilities, or field and develop a hypothesis based on a model or theory.
Ask and/or evaluate questions that challenge the interpretation of a data set.	Ask and/or evaluate questions that challenge the premise(s) of an argument.	Ask and evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.
Define a design problem that involves the development of a process or system with interacting components and state potential constraints.	Define a design problem that involves the development of a process or system with interacting components and established criteria. Identify constraints that may include social, technical and/or environmental considerations.	Define a design problem that involves the development of a process or system with interacting components, criteria and addresses constraints that include social, technical and/or environmental considerations.

Developing and Using Models

Beginning	Middle	End
Evaluate two different models of the same proposed tool, process, mechanism, or system to select a model that best fits the evidence or design criteria.	Evaluate two different models of the same proposed tool, process, mechanism, or system to select or revise a model that best fits the evidence or design criteria.	Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
Design a test of a given model.	Design a test of a given model to ascertain its reliability.	Design a test of a model to ascertain its reliability.
Use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	Develop a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.
Use models to provide mechanistic accounts and/or predict phenomena.	Develop and/or use models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.	Develop and use multiple types of models to provide mechanistic accounts, predict phenomena, and move flexibly between model types based on merits and limitations.
Analyze a model that allows for manipulation and testing of a proposed process or system.	Develop a model that allows for manipulation and testing of a proposed process or system.	Develop a complex model that allows for manipulation and testing of a proposed process or system.
Develop and/or use a model to generate data to analyze systems, and/or solve problems.	Develop and/or use a model to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Planning and Carrying Out Investigations

Beginning	Middle	End
Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.	Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.	Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.
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.	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.	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.
Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
Selects appropriate tools to collect and record data.	Selects appropriate tools to collect, record, and analyze data.	Select appropriate tools to collect, record, analyze, and evaluate data.
Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.	Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.	Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
Variables can be manipulated and data collected for a process or system to identify failure points for a given success criteria.	Variables can be manipulated and data collected for a process or a system to identify failure points or improve performance for a given success criteria.	Variables can be manipulated and data collected about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Analyzing and Interpreting Data

Beginning	Middle	End
Analyze data using provided tools, technologies, and/or models in order to determine if a claim is reliable or valid.	Analyze data using provided tools, technology, and/or a computational model to make a claim about a design solution.	Analyze data using provided tools, technology and/or a computational model to make a valid and reliable claim about a design solution.
Apply mathematics concepts of statistics such as correlation or linear fits to solve a scientific and engineering problem using digital tools.	Apply digital tools to compute statistics and probability of data (such as slope, intercept, correlation) to a scientific and engineering problem.	Use digital tools to apply concepts of statistics and probability to make data fit into slope, correlation, and intercept) to solve scientific and engineering questions and problems.
Students should analyze and interpret collected data to consider the limits of the instruments used and range of data.	Students should analyze and interpret the limitations (measurement error, sample size) of the collected data.	When analyzing and interpreting data, students consider the impact and limits of measurement errors, sample selections and such. Perhaps we should mention something about assumptions and limitations.
Compare various types of data sets to examine consistency of measurements and observations.	Contrast various types of data sets to examine consistency of measurements and observations.	Compare and contrast different data set types to look at the consistency of measurements and observations.
Identify the need for new data to confirm/modify a working explanation and/or model of a proposed process or system.	Assess the findings of new data on a working explanation or current model of a system.	Evaluate the impact of new data on a working explanation and/or model of a system.
Analyze data to determine design features needed for success.	Analyze data to identify design features needed for a successful system.	Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Using Mathematics and Computational Thinking

Beginning	Middle	End
Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.	Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.	Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
Revise a computational model or simulation of a phenomenon, designed device, process, or system.	Create a computational model/simulation of a phenomenon, device, or system.	Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
Use mathematical and/or algorithmic representations of phenomena to design solutions or to describe and/or support claims.	Use mathematical, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
Apply techniques of algebra to represent or solve scientific and engineering problems.	Apply algebra to solve scientific and engineering problems.	Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
Identify simple limit cases that can test mathematical expressions, computer programs, algorithms, or simulations of a process or system to compare outcomes with what is known in the real world.	Use simple tests (mathematical or computer based) to see if a model "makes sense" by comparing the outcomes to what is known about the real world.	Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world.
Use percent, rates, or unit conversions in problems using complicated measurements (such as derived units).	Apply ratios, rates, percentages, and unit conversions in measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).	Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

Constructing Explanations and Designing Solutions

Beginning	Middle	End
Make a qualitative and/or quantitative claim describing the relationship between independent and dependent variables.	Make a qualitative and/or quantitative claim describing the relationship between independent and dependent variables.	Make a qualitative and/or quantitative claim describing the relationship between independent and dependent variables.
Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.
Apply scientific concepts to provide an explanation of phenomena.	Apply scientific concepts to provide an explanation of phenomena.	Apply scientific concepts to provide an explanation of phenomena.
Substantiate and evaluate claims with evidence, reasoning, the existing body of scientific knowledge.	Apply reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning supports the claim.	Apply reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning supports the claim.
Engineering: Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	Engineering: Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	Engineering: Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.

Engaging in Argument from Evidence

Beginning	Middle	End
Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.	Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.	Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.	Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.	Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student generated evidence.	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student generated evidence.	Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student generated evidence.
Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Obtaining, Evaluating, and Communicating Information

Beginning	Middle	End
Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.	Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.	Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.	Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.	Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.	Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.	Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
Communicate scientific and/or technical information or ideas (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).	Communicate scientific and/or technical information or ideas (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).	Communicate scientific and/or technical information or ideas (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).

Appendix B- Scaffolded High School Crosscutting Concepts Clarifications

Patterns

Beginning	Middle	End
Different patterns can be used for evidence at different scales.	Patterns can be used for evidence at different scales. Different patterns can be used for evidence at different scales to provide evidence in explaining a phenomenon.	Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.
Recognize that classifications used at one scale may fail or need revising when info from a different scale is used.	To improve an investigation, scales may need to be smaller or larger. Recognize that explanations used at one scale may need revising when information from a different scale is used, requiring additional investigations.	Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced. This requires responding with improved investigations and experiments.
Patterns of performance of designed systems can be analyzed and interpreted to describe the system.	An analysis and/or interpretation of patterns from other systems can improve designs. Patterns of performance of designed systems can be analyzed and interpreted to suggest improvements to the system.	Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.
Mathematical representations are needed to identify some patterns.	Mathematical models (such as equations) and experimental data/observation can be used to identify some patterns.	Mathematical representations are needed to identify some patterns.
Experimental evidence is needed to identify patterns.	Experimental evidence is needed to identify patterns.	Experimental evidence is needed to identify patterns.

Cause and Effect: Mechanism and Prediction

Beginning	Middle	End
Recognize that experimental data is needed to differentiate between cause and correlation.	Use data to determine the difference between cause and correlation. Recognizing experimental evidence is needed to differentiate between cause and correlation and make a claim based on this evidence.	Experimental evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
Examine a small-scale system to understand cause and effect relationships.	Predict cause and effect relationships using what is known on a smaller scale.	Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
Design a system to make a specific effect occur.	Design a system to make something predictable happen.	Systems can be designed to cause a desired effect.
Changes in a system may cause unequal effects.	Changes in a system may have various causes that have unequal effect.	Changes in systems may have various causes that may not have equal effects.

Scale, Proportion & Quantity

Beginning	Middle	End
The significance of a phenomenon is affected by the scale, proportion, and quantity at which it occurs.	The significance of a phenomenon is affected by the scale, proportion, and quantity at which it occurs.	The significance of a phenomenon is affected by the scale, proportion, and quantity at which it occurs.
Some systems can only be studied indirectly as they are too small, too large, too fast, too far or too slow to observe directly.	Some systems can only be studied indirectly as they are too small, too large, too fast, too far or too slow to observe directly.	Some systems can only be studied indirectly as they are too small, too large, too fast, too far or too slow to observe directly.
Patterns observable at one scale may not be observable or exist at other scales.	Patterns observable at one scale may not be observable or exist at other scales.	Patterns observable at one scale may not be observable or exist at other scales.
Two different scaled models can be compared and related together.	Two different scaled models can be compared based on a given factor of magnitude and related together.	Scaled models can be compared and related together with varying orders of magnitude.
Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).	Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).	Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).

Systems and System Models

Beginning	Middle	End
Systems can be designed to do specific tasks.	Systems can be designed to do specific tasks.	Systems can be designed to do specific tasks.
System models should consider boundaries and initial conditions of the system	System models should consider the boundaries and initial conditions of the system and should include descriptions of inputs and outputs.	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.
Models can be used to represent systems and their interactions-such as inputs, processes and outputs-and energy, and matter flows within systems.	Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within or between systems at different scales.	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.
Models can be used to represent systems and their interactions-such as inputs, processes and outputs-and energy, and matter flows within systems.	Models can be used to predict the behavior of a system.	Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation

Beginning	Middle	End
In a closed system matter and energy is conserved.	Total energy and matter in a closed system is conserved.	The total amount of energy and matter in closed systems is conserved.
When change is applied to a system, both matter and energy can flow into and out of a system.	Energy and matter can flow into, out of, and within a system due to changes on a system.	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.
Energy can be transferred between objects, fields that mediate interaction at a distance, and systems made up of a collection of objects and fields.	Energy can be transferred between objects, fields that mediate interaction at a distance, and systems made up of a collection of objects and fields.	Energy cannot be created or destroyed. Energy only moves between one place and another place, between objects and/or fields, or between systems.
Matter cycles within and between systems.	Energy transfers as matter cycling in a system. Energy moves matter with and between systems.	Energy drives the cycling of matter within and between systems.
In the nuclear process the total number of protons plus neutrons is conserved.	In chemistry, atoms are conserved even in nuclear processes.	In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Structure and Function

Beginning	Middle	End
When investigating systems, identification of components and an explanation of how they work together is needed.	When investigating a system or structure components need to be examined and connections between components need to be made.	When investigating or designing new systems or structures, it's crucial to thoroughly examine the properties of various materials, the structures of different components, and how these components connect. This helps us understand their functions and find solutions to problems.
Functions of natural and designed objects and systems can be inferred from their structure. (Structure denotes function)	Functions of natural and designed objects and systems can be inferred from their structure. (Structure denotes function)	The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Stability and Change

Beginning	Middle	End
Much of science deals with constructing and testing explanations of how things change and/or stay the same.	Much of science deals with constructing and testing explanations of how things change and/or stay the same.	Much of science deals with constructing and testing explanations of how things change and/or stay the same.
Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.	Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.	Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.
Feedback can be positive or negative.	Feedback can be positive or negative and can change a system.	Feedback (negative or positive) can stabilize or destabilize a system.
Systems can be designed for greater or lesser stability.	Systems can be designed for greater or lesser stability.	Systems can be designed for greater or lesser stability.

Appendix C: Reading & Writing Standards for Literacy in Science and Technical Subjects

Reading

Grades 6-8

Key Ideas and Details

1. Cite specific textual evidence to support analysis of science and technical texts. (RST.6-8.1)
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. (RST.6-8.2)
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (RST.6-8.3)

Craft and Structure

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics. (RST.6-8.4)
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic. (RST.6-8.5)
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. (RST.6-8.6)

Integration of Knowledge and Ideas

7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (RST.6-8.7)
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (RST.6-8.8)
9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (RST.6-8.9)

Range of Reading and Level of Text Complexity

10. By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently. (RST.6-8.10)

Grades 9-10

Key Ideas and Details

1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. (RST.9-10.1)
2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text. (RST.9-10.2)
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. (RST.9-10.3)

Craft and Structure

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics. (RST.9- 10.4)
5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy). (RST.9-10.5)
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address. (RST.9-10.6)

Integration of Knowledge and Ideas

7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (RST.9-10.7)
8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (RST.9-10.8)
9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts. (RST.9-10.9)

Range of Reading and Level of Text Complexity

10. By the end of grade 10, read and comprehend science/technical texts in the grades 9–10 text complexity band independently and proficiently. (RST.9-10.10)

Grades 11–12

Key Ideas and Details

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. (RST.11-12.1)
2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (RST.11-12.2)
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text. (RST.11- 12.3)

Craft and Structure

4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. (RST.11- 12.4)
5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas. (RST.11-12.5)
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved. (RST.11-12.6)

Integration of Knowledge and Ideas

7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (RST.11-12.7)

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. (RST.11-12.8)
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (RST.11-12.9)

Range of Reading and Level of Text Complexity

10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently. (RST.11-12.10)

Writing

The standards below begin at grade 6; standards for K–5 writing in history/social studies, science, and technical subjects are integrated into the K–5 Writing standards. The CCR anchor standards and high school standards in literacy work in tandem to define college and career readiness expectations—the former providing broad standards, the latter providing additional specificity.

Grades 6–8

Text Types and Purposes

1. Write arguments focused on *discipline-specific content*.
    a. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
    b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
    c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.
    d. Establish and maintain a formal style appropriate for the task and audience.
    e. Provide a concluding statement or section that follows and supports the argument presented. (WHST.6-8.1)
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
    a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.
    b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples.
    c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts.
    d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
    e. Establish and maintain a formal style and objective tone appropriate for the task and audience.
    f. Provide a concluding statement or section that follows and supports the information or explanation presented. (WHST.6-8.2)
3. (See note; not applicable as a separate requirement) (WHST.6-8.3)

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (WHST.6-8.4)

5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed. (WHST.6-8.5)
6. Use technology to produce and publish writing to interact and collaborate with others through a variety of media to present the relationships between information and ideas efficiently. (WHST.6-8.6)

Research to Build and Present Knowledge

7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (WHST.6-8.7)
8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (WHST.6-8.8)
9. Draw evidence from informational texts to support analysis, reflection, and research. (WHST.6-8.9)

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. (WHST.6-8.10)

Grades 9–10

Text Types and Purposes

1. Write arguments focused on *discipline-specific content*.
    a. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
    b. Develop claim(s) and counterclaims, supplying data and evidence for each in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
    c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
    d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline.
    e. Provide a concluding statement or section that follows from or supports the argument presented. (WHST.9-10.1)
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
    a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
    b. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
    c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
    d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
    e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.

    f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic). (WHST.9-10.2)
3. (See note; not applicable as a separate requirement) (WHST.9-10.3)

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (WHST.9-10.4)
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. (WHST.9-10.5)
6. Use technology to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically. (WHST.9-10.6)

Research to Build and Present Knowledge

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. (WHST.9-10.7)
8. Gather relevant information from multiple credible primary and secondary print and digital sources, using advanced searches effectively; assess the usefulness of each source, including recognition of bias in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation. (WHST.9-10.8)
9. Draw evidence from informational texts to support analysis, reflection, and research. (WHST.9-10.9)

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. (WHST.9-10.10)

Grades 11–12

Text Types and Purposes

1. Write arguments focused on *discipline-specific content*.
    a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
    b. Develop claim(s) and counterclaims, supplying the most relevant data and evidence for each in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
    c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
    d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline.
    e. Provide a concluding statement or section that follows from or supports the argument presented by summarizing main points. (WHST.11-12.1)
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
b. Develop the topic clearly and thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
d. Use precise language, domain-specific vocabulary and techniques, such as figures of speech or text structure, to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
e. Provide a concluding statement or section that follows from and supports the information or explanation provided that includes articulating implications or the significance of the topic. (WHST.11-12.2)

3. (See note; not applicable as a separate requirement) (WHST.11-12.3)

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (WHST.11-12.4)
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. (WHST.11-12.5)
6. Use technology to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information. (WHST.11-12.6)

Research to Build and Present Knowledge

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. (WHST.11-12.7)
8. Gather relevant information from multiple credible primary and secondary print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience, including recognition of bias; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (WHST.11-12.8)
9. Draw evidence from informational texts to support analysis, reflection, and research. (WHST.11-12.9)

Range of Writing

10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. (WHST.11-12.10)

Note: Students' narrative skills continue to grow 6-12. The Standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work that others can replicate them and (possibly) reach the same results.

Appendix D: Supplemental High School Electives

These standards were created specifically for high school students to ensure developmentally appropriate learning that builds upon the Iowa Academic Standards in Science. The courses aim to promote enduring and age-appropriate learning, equipping students with the knowledge and understanding necessary for an informed citizenry. By embracing the principles of scientific thinking, students will be better prepared to make thoughtful decisions. All Iowa Science Standards are grounded in the essence of science, the processes through which it is learned, and the various dimensions of scientific practice.

The following standards are not mandatory for all students but serve as a framework for districts in developing and implementing standards for elective courses. These courses were selected based on research into elective offerings in Iowa high schools that complement the required Iowa Academic Standards for Science. Other elective courses should also adopt a similar three-dimensional approach to ensure the standards are valuable, relevant, and applicable to students' lives.

Human Anatomy and Physiology Supplemental Standards

When students engage with the Human Anatomy and Physiology Supplemental Standards they develop and use models to illustrate anatomical structures and regions of the human body. Students construct explanations of how the integumentary, skeletal and muscular systems make support, protection, and movement possible. Students analyze and interpret data to understand how the endocrine and nervous systems make information processing possible. Students ask questions about the relationships between the cardiovascular, respiratory, digestive, and urinary systems. Students obtain, evaluate, and communicate information about the male and female reproductive systems that make conception, development, and birth of human life possible.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P1-1	**Develop and use models to demonstrate the orientation of anatomical structures and regions of the human body.**	**Developing and Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Anatomical Structures of the Human Body:** Identify how size, orientation, and location within the human body support the function of the anatomical structures.	**Structure and function:** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, how their components are shaped and used, and the molecular substructures of their various materials.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P1-2	**Obtain, evaluate, and communicate information about how the scale, proportion, and quantity of different body structures affect their functions within the human body.**	**Obtaining, Evaluating, and Communicating Information:** Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) and in words to address a scientific question or solve a problem.	**Anatomical Structures of the Human Body:** Evaluate the roles of cells, tissues, organs, and organ systems.	**Systems and System Models:** Some systems can only be studied indirectly as they are too small, too large, too fast, too far or too slow to observe directly. **Structure and function:** Systems are designed to do specific tasks within the parameters of homeostasis.

Iowa is home to multiple medical and natural history museums that offer virtual and in person tours.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P2-1	**Construct an explanation about the relationship between the structures and functions of the integumentary system**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Integumentary System** The integumentary system plays an important role in protection, eliminating waste products, and regulating body temperature through physiological homeostatic processes.	**Structure and function:** Systems are designed to do specific tasks within the parameters of homeostasis.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P2-2	**Develop and use models to relate the structure and functions of the skeletal system.**	**Developing and Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Skeletal System** The skeletal system provides the body with movement, protection, support, and storage of minerals through physiological homeostatic processes.	**Structure and function:** Systems are designed to do specific tasks within the parameters of homeostasis.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P2-3	**Develop and use a model to investigate the cause and effect relationship between structure and functions of the muscular system and their role in movement and support.**	**Developing and Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Muscular Systems** The muscular system also provides the body with movement and support through physiological homeostatic processes.	**Cause and effect:** Cause and effect relationships can be used to predict natural systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P2-4	**Engage in argument from evidence about how the integumentary, skeletal, and muscular systems make support, protection, and movement possible.**	**Engaging in Argument from Evidence:** Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Integumentary, Skeletal and Muscular Systems:** Analyze the homeostatic mechanisms, as well as the effects of and responses to nutrition, aging, diseases, and disorders.	**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.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P3-1	**Plan and carry out an investigation to determine how the structures of the nervous system support the function of information processing (detection, interpretation, and response) within the body.**	**Planning and Carrying Out Investigations:** 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.	**Nervous System:** The nervous system is the body's means of information processing. The endocrine system regulates the physical and chemical processes of the body. The endocrine and nervous systems work together to help the body process information.	**Structure and Function:** Systems are designed to do specific tasks within the parameters of homeostasis.

Iowa is home to multiple universities and medical facilities where students can go or speakers on health subjects can come in.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P3-2	**Develop and use a model to investigate the cause and effect relationship between the hormones of the endocrine system and the homeostatic processes they regulate to maintain a stable internal environment, support health, and promote growth and development.**	**Analyzing and Interpreting Data:** When analyzing and interpreting data, students consider the impact and limits of measurement errors, sample selections and such.	**Endocrine System:** Explain both positive and negative feedback mechanisms. Examples of feedback mechanisms could be heart rate, blood sugar, childbirth, temperature, and growth.	**Structure and Function:** Systems are designed to do specific tasks within the parameters of homeostasis. **Cause and effect:** Cause and effect relationships can be used to predict natural systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P3-3	**Construct an explanation about how the cause and effect relationship of the endocrine and nervous systems makes information processing (detection, interpretation and response) possible.**	**Engaging in Argument from Evidence:** Apply reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning supports the claim.	**Endocrine and Nervous System:** Emphasize homeostatic mechanisms and their effects and responses to nutrition, aging, diseases, and disorders.	**Structure and Function:** Systems are designed to do specific tasks within the parameters of homeostasis. **Cause and Effect:** Systems can be designed to cause a desired effect.

Although scientific knowledge is durable, scientific knowledge is open to revision in light of new evidence.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P4-1	**Develop and use a model to investigate the cause and effect relationship that explains how the cardiovascular and respiratory systems obtain oxygen, transport nutrients, and remove waste.**	**Developing and Using Models:** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Cardiovascular and Respiratory Systems** The cardiovascular and respiratory system help the body obtain oxygen, transport nutrients, and remove waste. The digestive and urinary systems help the body obtain nutrients and eliminate waste. The cardiovascular, respiratory, urinary, and digestive systems are interdependent yet responsive to each other. Measurements of cardiovascular, respiratory, digestive, and urinary systems processes can indicate the relative health of the body.	**Structure and Function:** Systems are designed to do specific tasks within the parameters of homeostasis. **Cause and Effect:** Systems can be designed to cause a desired effect.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P4-2	**Obtain, evaluate, and communicate information about the relationship between the structure and function of the digestive and urinary systems as they utilize matter to derive energy and eliminate waste.**	**Obtaining, Evaluating, and Communicating Information:** Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.	**Digestive and Urinary Systems** The cardiovascular and respiratory system help the body obtain oxygen, transport nutrients, and remove waste. The digestive and urinary systems help the body obtain nutrients and eliminate waste. The cardiovascular, respiratory, urinary, and digestive systems are interdependent yet responsive to each other. Measurements of cardiovascular, respiratory, digestive, and urinary systems processes can indicate the relative health of the body.	**Structure and Function:** Systems are designed to do specific tasks within the parameters of homeostasis. **Cause and Effect:** Systems can be designed to cause a desired effect.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P4-3	**Ask questions to construct an explanation about the interdependence of the cardiovascular, respiratory, immunity, lymphatic urinary, and digestive systems.**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information	**Cardiovascular, Respiratory, Digestive, and Urinary Systems:** Interpret homeostatic mechanisms, as well as the effects of and responses to nutrition, aging, diseases, and disorders.	**Systems and System Models:** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Biomedical engineering designs solutions to complex real-world problems affecting body systems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P4-4	**Use mathematics and computational thinking to design a device which measures the exchange of matter and energy used by the cardiovascular, respiratory, immunity, lymphatic, digestive, and urinary systems to determine health of those systems and to prevent potential health issues.**	**Asking Questions and Defining Problems:** Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution.	**Cardiovascular, Respiratory, Digestive, and Urinary Systems:** Examples of measurements could include caloric input to the digestive system, respiratory gas output, respiratory rates, respiratory volumes, digestive rates, heat lost by urine output, blood pressure, and heart rate.	**Energy and Matter:** Energy drives the cycling of matter within and between systems.

Technology and science interact in interesting ways. New technologies result in new observations and new scientific conclusions can inform technological development.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P5-1	**Develop and use a model to investigate the cause and effect relationship between the structures of the male and female reproductive system environments allowing for the production of egg and sperm, fertilization, implantation, and the development of the human fetus.**	**Developing and Using Models** Develop and use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Reproductive System's Role in the Growth and Development of Humans** Illustrate the role of hormones in the male and female reproductive process and the stages of fetal development.	**Structure and function:** Systems are designed to do specific tasks within the parameters of homeostasis. **Cause and Effect:** Systems can be designed to cause a desired effect.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-A&P5-2	**Ask questions about how the reproductive system uses matter and energy to make growth and development possible.**	**Asking Questions and Defining Problems:** Ask questions that arise from examining models or a theory, to clarify and seek additional information and relationships.	**Reproductive System's Role in the Growth and Development of Humans:** Analyze homeostatic mechanisms, as well as the effects of and responses to nutrition, aging, diseases, and disorders.	**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.

Astronomy Supplemental Standards

The Astronomy High School Supplemental Iowa Science Standards delve into the patterns, forces, relationships, and systems of matter and energy throughout the Universe. Students engage in modeling and investigating patterns observed both on Earth and in the night sky, examining phenomena that impact life on our planet. They pose questions, model objects within our solar system, and design potential solutions for future human colonization beyond Earth. Additionally, students construct models and formulate arguments regarding the life cycles of stars, predicting their final stages based on mass. Through these explorations, students develop models that explain the formation and characteristics of the universe itself.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST1-1	**Develop and use models to evaluate the relationship between the relative positions of the Earth, Sun, and Moon and the phenomena caused by the relationship as observed from Earth.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Patterns Observed on Earth and in the Night Sky Affect Life on Earth and Space Exploration:** Examples of observable phenomena may include the day/night cycle, seasons, equinoxes and solstices, moon phases, eclipses, or tides. Earth has experienced a cycle of ice ages. This cycle is explained by changes in Earth's orbit and tilt change over hundreds of thousands of years altering the intensity and distribution of sunlight on Earth.	**Cause and Effect:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Although scientific knowledge is durable, scientific knowledge is open to revision in light of new evidence.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST1-2	**Plan and carry out an investigation using the celestial sphere to explain how latitude and time of year affect the visibility of constellations, planets, and other celestial objects.**	**Planning and Carrying out Investigations:** Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible variables or effects and evaluate the confounding investigation's design to ensure variables are controlled.	**Patterns Observed on Earth and in the Night Sky Affect Life on Earth and Space Exploration:** The study of astronomy started as curious people observed and tried to explain phenomena observed on Earth by looking up at the sky. Models help to investigate and explain these phenomena using evidence for our current understanding. Space Exploration helps us better understand our planet and cause leaps in technology, culture, knowledge, and inspiration.	**Cause and Effect:** Systems can be designed to cause a desired effect.

Iowa is home to multiple observatories and many public libraries have telescopes.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST1-3	**Obtain, evaluate, and communicate information about how patterns in ancient structures, instruments, philosophies, and civilizations influenced the study of astronomy.**	**Obtaining, Evaluating, and Communicating Information:** Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	**Patterns Observed on Earth and in the Night Sky Affect Life on Earth and Space Exploration:** Examples of philosophies could include astronomical models (e.g., geocentric, heliocentric), Aristotelian physics, or Ptolemaic models with epicycles.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

Technology and science interact in interesting ways. New technologies result in new observations and new scientific conclusions can inform technological development.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST1-4	**Plan and carry out an investigation to analyze patterns in telescopic data of various electromagnetic spectra to explain astronomical phenomena.**	**Planning and Carrying out Investigations:** 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.	**Patterns Observed on Earth and in the Night Sky Affect Life on Earth and Space Exploration:** Emphasize evaluating the uses and advantages of data to explain phenomena. Examples of data of various electromagnetic spectra could include absorption, redshift/blueshift, emission spectra, or blackbody curves.	**Patterns:** Different patterns may be observed at each of the scales at which a system is studied. These patterns can provide evidence for causality in explaining phenomena.

James Van Allen, a professor at the University of Iowa, discovered the Van Allen Radiation Belts that encompass the Earth.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST1-5	**Construct an argument based on evidence for the significance of historical and future space exploration as they relate to affecting leaps in technology, cultural cooperation, knowledge, and inspiration.**	**Constructing Explanations and Designing Solutions:** Construct and revise an explanation based on evidence from a variety of sources and the existing body of scientific knowledge.	**Patterns Observed on Earth and in the Night-Sky Affect Life on Earth and Space Exploration:** Emphasize that historical space exploration began with Sputnik and continues to the present day. Examples include the orbiting earth with John Glenn, Neil Armstrong and the moon landing, the Voyager space probes, the Hubble Space telescope and the James Webb Telescope.	**Cause and Effect:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Constructing arguments via writing and speaking.

Space exploration and engineering fields continue to evolve and generate new opportunities.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST2-1	**Ask questions to investigate and communicate the structure and properties of objects in our solar system and the zones they inhabit. Emphasize grouping the objects found in the solar system into different categories based on their major properties.**	**Asking Questions and Defining Problems:** Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information.	**Structures in the Solar System and Their Formation:** Examples of objects in the solar system could include planets, dwarf planets, major moons, asteroids, or comets. Examples of zones could include the asteroid belt, Kuiper belt, or the Oort cloud.	**Systems and System Models:** When investigating or designing new systems or structures, it's crucial to thoroughly examine the properties of various materials, the structures of different components, and how these components connect. This helps us understand their functions and find solutions to problems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST2-2	**Develop and use models, based on evidence, to explain the formation of the solar system and the different proportions of matter and energy within regions of the system.**	**Developing and Using Models:** Develop and use multiple types of models to provide mechanistic accounts, predict phenomena, and move flexibly between model types based on merits and limitations.	**Structures in the Solar System and Their Formation:** Emphasize the cause of observed patterns of matter distribution in the solar system. Examples of matter distribution could include low amounts of ice found inside the frost line or the location of gas planets.	**Systems and System Models:** Some systems can only be studied indirectly as they are too small, too large, too fast, too far or too slow to observe directly.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST2-3	**Use computational thinking to model gravitational force at varying scale and proportion that explain motion and interaction of objects in the solar system.**	**Using Mathematics and Computational Thinking:** Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Structures in the Solar System and Their Formation:** Emphasize that these forces are also at play throughout the universe. Examples of models could be conceptual, comparing force and motion of different objects in space, and do not require that students solve for the force of gravity acting on an object.	**Scale Proportion and Quantity:** Mathematical (i.e., algebraic) thinking is used to examine scientific data and predict the effect changing one variable has on another (e.g., linear growth vs. exponential growth).

Mathematics often supports scientific investigations through mathematical modeling. Within this standard, mathematical and computational thinking may include algebraic expressions, graphs, simulations, and mathematical models.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST2-4	**Design a solution for a functioning human colony on an object in the solar system other than Earth.**	**Developing and Using Models:** Design, evaluate, or refine a solution to solve a problem while considering unintended consequences of possible solutions.	**Structures in the Solar System and Their Formation:** Emphasize analyzing which planet/world of the solar system would have the best chance for a successful colony based on specific criteria. Examples of planets/worlds of the solar system could include Mars or moons of the Jovian planets. Examples of specific criteria could include distance from Earth, available energy sources, amounts of water or solvent, protection from solar radiation, or amount of resources/building materials.	**Systems and System Models:** When investigating or designing new systems or structures, it's crucial to thoroughly examine the properties of various materials, the structures of different components, and how these components connect. This helps us understand their functions and find solutions to problems.

Space exploration and engineering fields continue to evolve and generate new opportunities.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST3-1	**Develop and use models to explain stability and change during the process of stellar evolution from birth to death of a star.**	**Developing and Using Models:** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**Stability and Change in the Life of Stars:** Emphasize the causes for the changes during stellar evolution and the evidence that supports current understanding.	**Stability and Change:** Change and rates of change can be quantified and modeled over varied time frames from very short to very long. Some system changes are irreversible.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST3-2	**Construct an argument on the constructive and destructive lifecycle of a star based on evidence.**	**Constructing Explanations and Designing Solutions:** Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, considering possible unanticipated effects.	**Stability and Change in the Life of Stars:** Using a Hertzsprung-Russell diagram as a starting point, examine properties of stars that may include density, luminosity, temperature, rates of fusion, absolute magnitude, or spectral class.	**Structure and Function:** When investigating or designing new systems or structures, it's crucial to thoroughly examine the properties of various materials, the structures of different components, and how these components connect. This helps us understand their functions and find solutions to problems.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST3-3	**Ask questions to evaluate evidence that predicts the stability and change of a star during its lifespan and its final stage of stellar evolution based on mass.**	**Asking Questions and Defining Problems:** Ask questions that arise from examining models or a theory, to clarify and seek additional information and relationships.	**Stability and Change in the Life of Stars:** A star's lifespan can be predicted based on its mass and core elements acquired during accretion. Emphasize the entire lifespan including stellar remnants and final stages such as white dwarfs, neutron stars, pulsars, black holes, and supernovae.	**Stability and Change:** Much of science deals with constructing and testing explanations of how things change and/or stay the same.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST4-1	**Construct an argument from evidence to explain the patterns that describe the formation of the universe.**	**Constructing Explanations and Designing Solutions:** Make a qualitative and/or quantitative claim describing the relationship between independent and dependent variables.	**Stability and Change in the Life of Stars:** Emphasize the scientific theory of the Big Bang and the evidence that supports it. Examples of evidence for the Big Bang could include the cosmological principle, cosmic microwave background radiation, Hubble's Law, observed galactic redshift, and time-space expansion.	**Patterns:** Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced. This requires responding with improved investigations and experiments.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST4-2	**Use models to describe the conditions of the early universe that led to the formation and evolution of matter including the birth of the first stars and galaxies.**	**Developing and Using Models:** Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.	**Stability and Change in the Life of Stars:** Stars are born and die over a period of time in a process called stellar evolution. During a star's existence they may change in elemental composition, density, luminosity, temperature, and other ways. These changes can both be recognized and predicted using evidence provided by other celestial objects. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**Change and Stability:** Much of science deals with constructing explanations of how things change and how they remain stable.

While models have limitations, scientists use models to generate and test their ideas about the natural world.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST4-3	**Construct an explanation using evidence to support the existence of dark matter and dark energy.**	**Constructing Explanations and Designing Solutions:** Apply scientific reasoning to connect evidence to a claim and evaluate the extent that the data and reasoning support the claim.	**Stability and Change in the Life of Stars:** Emphasize indirect evidence to support their existence. Indirect evidence of dark matter includes rotational curves in galaxies, interactions with other galaxies (e.g. Coma Cluster, Bullet Cluster) and the fluctuations of Cosmic Microwave Background. New discoveries are still being made as scientists search for the presence and influences of dark matter.	**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.

Standard Code	Iowa Academic Standard in Science	Science Practice Clarification	Disciplinary Core Idea Clarification	Crosscutting Concept Clarification
HS-AST4-4	**Develop and use models to relate the cause for how galactic evolution occurs.**	**Developing and Using Models:** Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.	**Stability and Change in the Life of Stars:** Emphasize the processes of mergers and collisions (e.g. The Mice collision, Messier 51, Taffy Galaxies). Reference could also be made about the impending collision between the Milky Way and Andromeda galaxies.	**Cause and Effect:** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

While models have limitations, scientists use models to generate and test their ideas about the natural world.

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