Indiana Academic Standards
Science

Environmental Science

K-12 Science Indiana Academic Standards Overview

The K-12 Science Indiana Academic Standards are based on *A Framework for K-12 Science Education* (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). They are meant to reflect a new vision for science education. The following conceptual shifts reflect what is new about these science standards. The K-12 Science Indiana Academic Standards:

- Reflect science as it is practiced and experienced in the real world;
- Build logically from kindergarten through grade 12;
- Focus on deeper understanding as well as application of content; and
- Integrate practices, crosscutting concepts, and core ideas.

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

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

Science and Engineering Practices (*as found in NGSS*)

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

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

Crosscutting Concepts (*as found in NGSS*)

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

1. *Patterns.* Observed patterns of forms and events guide organization and classification, and prompt questions about relationships and the factors that influence them.
2. *Cause and Effect: Mechanism and Explanation*. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated.

Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

3. *Scale, Proportion, and Quantity.* In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
4. *Systems and System Models.* Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
5. *Energy and Matter: Flows, Cycles, and Conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
6. *Structure and Function.* The way in which an object or living thing is shaped and its substructure determines many of its properties and functions.
7. *Stability and Change.* For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Disciplinary Core Ideas (*as found in NGSS*)

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

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

The K-12 Science Indiana Academic Standards are not intended to be used as curriculum. Instead, the standards are the minimum that students should know and be able to do. Therefore, teachers should continue to differentiate for the needs of their students by adding depth and additional rigor.

References:

- National Research Council. 2012. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165.
- NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

How to read the revised Science Indiana Academic Standards

Standard Number **Title** The title for a set of performance expectations is not necessarily unique and may be reused at several different grade levels.

Students who demonstrate understanding can:

Standard Number **Performance Expectation: A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.** [Clarification Statement: A statement that supplies examples or additional clarification to the performance expectation.]

Science and Engineering Practices

Science and Engineering Practices are activities that scientists and engineers engage in to either understand the world or solve the problem.

There are 8 practices. These are integrated into each standard. They were previously found at the beginning of each grade level content standard and known as SEPs.

Connections to the Nature of Science

Connections are listed in either practices or the crosscutting concepts section.

Disciplinary Core Ideas

Disciplinary Core Ideas are concepts in science and engineering that have broad importance within and across disciplines as well as relevance in people's lives.

To be considered core, the ideas should meet at least two of the following criteria and ideally all four:

- Have broad importance across multiple sciences or engineering disciplines or be a key organizing concept of a single discipline.
- Provide a key tool for understanding or investigating more complex ideas and solving problems.
- Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.
- Be teachable and learnable over multiple grades at increasing levels of depth and sophistication.

Disciplinary ideas are grouped in four domains: the physical sciences; the life sciences; the earth and space sciences; and engineering, technology, and applications of science.

Crosscutting Concepts

Crosscutting concepts are seven ideas such as Patterns and Cause and Effect, which are not specific to any one discipline but cut across them all.

Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas.

Connections to Engineering, Technology and Applications of Science

These connections are drawn from either the Disciplinary Core Ideas or Science and Engineering Practices.

HS-ENV1-1 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-1. **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.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

Reference: NGSS HS-LS2-6

Science and Engineering Practices

SEP.7: Engaging in Argument from Evidence

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

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

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Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest 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.

Crosscutting Concepts

CC.7: Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

HS-ENV1-2 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-2.* **Use a computational representation to illustrate that humans are part of Earth's ecosystems and how human activities can, deliberately or inadvertently, alter ecosystems.**

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

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

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

CC.4: 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.

HS-ENV1-3 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-3. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.]

Reference: NGSS HS-ESS3-6

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

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

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

CC.4: 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.

HS-ENV1-4 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-4.* **Analyze data regarding differences between systems in equilibrium and systems in disequilibrium. Use corresponding data to support how steady state is achieved through negative and positive feedback loops.**

Science and Engineering Practices

SEP.4: Analyzing and Interpreting Data

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

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

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

ESS2.D: Weather and Climate

- 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.

Crosscutting Concepts

CC.7: Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.

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Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- 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.

* Denotes Indiana Specific Standard

HS-ENV1-5 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-5.* **Evaluate, measure, and communicate biological, chemical, and physical (abiotic and biotic) factors within an ecosystem.**

Science and Engineering Practices

SEP.8: Obtaining, Evaluating, and Communicating Information

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

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

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Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

Disciplinary Core Ideas

ESS2.A: Earth Materials and Systems

- Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.

Crosscutting Concepts

CC.4: 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.

* Denotes Indiana Specific Standard

HS-ENV1-6 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-6.* **Use a model to locate and describe the major Earth biomes. Analyze data to assess how biomes are determined by climate (temperature and precipitation patterns) that support specific kinds of plants.**

Science and Engineering Practices

SEP.2: Developing and Using Models

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

- Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- 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.

Crosscutting Concepts

CC.4: 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.

HS-ENV1-7 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-7.* **Observe the difference between weather and climate.
Observe how weather can be influenced by global climatic patterns, such as El Niño and La Niña.
Use a model or simulation to observe the factors that influence weather and climate, the action of gravitational forces, and the rotation of the Earth.**

Science and Engineering Practices

SEP.2: Developing and Using Models

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

- Use a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- 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.

Crosscutting Concepts

CC.4: 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.

* Denotes Indiana Specific Standard

HS-ENV1-8 Environmental Systems

Students who demonstrate understanding can:

HS-ENV1-8. **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 change and associated future impacts to Earth systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, should show how projected climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition) are dependent on emission scenarios.]

Reference: NGSS HS-ESS3-5

Science and Engineering Practices

SEP.4: Analyzing and Interpreting Data

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

- Analyze data using computational models in order to make valid and reliable scientific claims.

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Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

Disciplinary Core Ideas

ESS3.D: Global Climate Change

- Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.

Crosscutting Concepts

CC.7: Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

HS-ENV2-1 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-1.* **Construct and revise an explanation based on evidence for the cycling of matter through sources and sinks and how energy is transferred.**

Science and Engineering Practices

SEP.6: Constructing Explanations and Designing Solutions

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

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

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Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

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

Disciplinary Core Ideas

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.

Crosscutting Concepts

CC.5: Energy and Matter

- Energy drives the cycling of matter within and between systems.

* Denotes Indiana Specific Standard

HS-ENV2-2 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-2. **Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** ***(These mathematical representations may include ecological pyramids of number, biomass, and energy.)***

Reference: NGSS HS-LS2-4

Science and Engineering Practices

SEP.5: Using Mathematical and Computational Thinking

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

- Use mathematical representations of phenomena or design solutions to support claims.

Disciplinary Core Ideas

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.

Crosscutting Concepts

CC.5: Energy and Matter

- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

HS-ENV2-3 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-3. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, 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.]

Reference: NGSS HS-ESS2-4

Science and Engineering Practices

SEP.2: Developing and Using Models

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

- Use a model to provide mechanistic accounts of phenomena.

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Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

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

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*

ESS2.A: Earth Materials and System

- The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

ESS2.D: Weather and Climate

- 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.

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HS-ENV2-4 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-4.* **Analyze and interpret the data on the benefits and disadvantages of the different sources of energy including fossil fuels, nuclear energy, hydroelectric, wind, solar, geothermal and biofuels.**

Science and Engineering Practices

SEP.4: Analyzing and Interpreting Data

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

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

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding Environment.

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.

Crosscutting Concepts

CC.5: Energy and Matter

- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems

HS-ENV2-5 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-5.* **Use a model or simulation to analyze how layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. Observe that by burning these fossil fuels, people are passing stored energy back into the environment as heat and releasing large amounts of matter such as carbon dioxide and other air pollutants.**

Science and Engineering Practices

SEP.2: Developing and Using Models

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

- Use a model to provide mechanistic accounts of phenomena.

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.

Crosscutting Concepts

CC.5: Energy and Matter

- Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

* Denotes Indiana Specific Standard

HS-ENV2-6 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-6. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen. Discuss how environmental costs can be left out of cost-benefit analyses.]

Reference: NGSS HS-ESS3-2

Science and Engineering Practices

SEP.7: Engaging in Argument from Evidence

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

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

Disciplinary Core Ideas

ESS3.A: Natural Resources

- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Engineers continuously modify these 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.

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Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.
- 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.

HS-ENV2-7 Flow of Matter and Energy

Students who demonstrate understanding can:

HS-ENV2-7.* **Analyze computational tools and other technologies that allow for the management of natural resources. Evaluate the trade-offs of these tools regarding human physical and cultural needs versus sustainability and biodiversity.**

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

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

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Crosscutting Concepts

CC.7: Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

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

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Connections to Nature of Science

Science is a Human Endeavor

- Science is a result of human endeavors, imagination, and creativity.

* Denotes Indiana Specific Standard

HS-ENV3-1 Natural Hazards

Students who demonstrate understanding can:

HS-ENV3-1.* **Construct an explanation based on evidence for how natural Earth hazards, such as earthquakes, tornadoes, and hurricanes, affect the environment and human activity on both a short-term and long-term scale.** [Clarification Statement: Discuss and evaluate the hazard, exposure, and vulnerability of human populations based upon the development of society].

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.6: Constructing Explanations and Designing Solutions

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

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

ESS3.A: Natural Resources

- Resource availability has guided the development of human society.

ESS3.B: Natural Hazards

- Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems.

* Denotes Indiana Specific Standard

HS-ENV4-1 Biodiversity

Students who demonstrate understanding can:

HS-ENV4-1.* **Use a model or simulation to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.**

Science and Engineering Practices

SEP.2: Developing and Using Models

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

- Use a model to provide mechanistic accounts of phenomena.
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Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest 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.

Crosscutting Concepts

CC.3: Scale, Proportion, and Quantity

- Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

HS-ENV4-2 Biodiversity

Students who demonstrate understanding can:

HS-ENV4-2. **Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** [Clarification Statement: Examples of human activities can include urbanization, building dams, hunting, pollution, bioaccumulation and biomagnification of toxins, and dissemination of invasive species.]

Reference: NGSS HS-LS2-7

Science and Engineering Practices

SEP.6: Constructing Explanations and Designing Solutions

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

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- Moreover, anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species.

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints including cost, safety, reliability, and aesthetics and to consider social, cultural and environmental impacts. *(secondary)*

Crosscutting Concepts

CC.7: Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

HS-ENV5-1 The Effect of Human Population and Activities on the Environment

Students who demonstrate understanding can:

HS-ENV5-1.* **Analyze and interpret data on how the size and rate of growth of the human population in any location is affected by economic, political, religious, technological, and environmental (resource availability) factors.**

Science and Engineering Practices

SEP.4: Analyzing and Interpreting Data

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

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

Disciplinary Core Ideas

LS4.D: Biodiversity and Humans

- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary)*
- Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)*

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems.

* Denotes Indiana Specific Standard

HS-ENV5-2 The Effect of Human Population and Activities on the Environment

Students who demonstrate understanding can:

HS-ENV5-2. **Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.** [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.]

Reference: NGSS HS-ESS3-3

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

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

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

Crosscutting Concepts

CC.7: Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

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

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Connections to Nature of Science

Science is a Human Endeavor

- Science is a result of human endeavors, imagination, and creativity.

HS-ENV5-3 The Effect of Human Population and Activities on the Environment

Students who demonstrate understanding can:

HS-ENV5-3. **Design, evaluate and refine a technological solution that reduces impacts of human activities on natural systems.** [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources, including water conservation efforts) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).]

Reference: NGSS HS-ESS3-4

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.6: Constructing Explanations and Designing Solutions

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

- Design or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

CC.7: Stability and Change

- Feedback (negative or positive) can stabilize or destabilize a system.

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Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

HS-ENV5-4 The Effect of Human Population and Activities on the Environment

Students who demonstrate understanding can:

HS-ENV5-4. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.]

Reference: NGSS HS-ESS3-6

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.5: Using Mathematics and Computational Thinking

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

- Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.

Disciplinary Core Ideas

ESS2.D: Weather and Climate

- Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*

ESS3.D: Global Climate Change

- Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.

Crosscutting Concepts

CC.4: 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.

HS-ENV6-1 Environmental Policy

Students who demonstrate understanding can:

HS-ENV6-1.* **Conduct an investigation to evaluate the effectiveness of environmental policies and/or organizations (Clean Water Act, Clean Air Act, Endangered Species Act, Species Survival Plan, Resource Conservation and Recovery Act, Department of Energy, and the World Health Organization).**

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.6: Constructing Explanations and Designing Solutions

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

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ETS1.B: Developing Possible Solutions

- When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*.

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

- -

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Modern civilization depends on major technological systems.

HS-ENV6-2 Environmental Policy

Students who demonstrate understanding can:

HS-ENV6-2.* **Construct an argument to explain that environmental policies/decisions have negative and positive impacts on people, societies, and the environment.**

The performance expectation above was developed using the following elements from *A Framework for K-12 Science Education*:

Science and Engineering Practices

SEP.7: Engaging in Argument from Evidence

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

- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

ETS1.B: Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*

Crosscutting Concepts

CC.2: Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

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Connections to Engineering, Technology, and Applications of Science

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