Washington State

K - 12 Science

Learning Standards

June 2009

SUPERINTENDENT OF PUBLIC INSTRUCTION WASHINGTON

Randy I. Dorn
State Superintendent of Public Instruction

Washington State K-12 Science Learning Standards

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June 2009
Version 1.2 June 2010

A Message from Superintendent Randy Dorn

Superintendent of Public Instruction

June 15, 2009

More than 15 years ago I was one of the sponsors of the Basic Education Act of 1993, which promised the people of Washington an educational system that would: “Provide students with the opportunity to become responsible and respectful global citizens, to contribute to their own economic well-being and that of their families and communities, to explore and understand different perspectives, and to enjoy productive and satisfying lives.”

I was very proud of the framework the Act established for the success of our students. And since 1993, I’ve watched closely as our Legislature, governor, and educators at every level of our educational system have been hard at work, doing all in their power to fulfill that commitment. The domain of science and technology is an especially important segment of every child’s education. Science provides the key to understanding the world we live in, and the ability to ask and answer meaningful questions. Technology offers tools for extending our senses and realizing our dreams. Together, a solid understanding and capability in science and technology can help today’s children solve tomorrow’s critical environmental, economic, and societal problems, and build a safe and secure life for themselves and their families.

The foundation for a strong and coherent state science education system is a set of educational standards. Every few years the standards are revised to take advantage of new developments in science and education, and to ensure that we remain up-to-date. This document is the third version of our science standards since 1993. This new version of *Washington State K-12 Science Standards* responds to a critical review of our previous standards by David Heil and Associates, commissioned by our State Board of Education (SBE), and endorsed by a Science Advisory Panel convened by the SBE. The report found that in comparison with other state and national documents, the Washington standards were “good,” but made 11 recommendations for how the standards can become “excellent.” The report was given to the superintendent’s office to implement in May 2008, and the recommendations were carried out by the Science Standards Revision Team, a group of 32 of our state’s most experienced teachers and educational leaders. Cary I. Sneider Inc., whose members have extensive national experience in science education, provided technical support.

In addition to implementing the recommendations from the State Board of Education, my staff has visited many schools in the state and talked with hundreds of science educators. Their support of the basic tenets of the previous standards and desires for a document that is easier to navigate and more manageable to implement, also have guided our efforts to transform our standards from “good” to “excellent.” The voice of Washington State formal and informal science educators, administrators, community members, business leaders, and many other stakeholder groups are clearly heard in this document. Those same voices and others will guide our implementation process as give all students in Washington State the opportunity to learn and apply science. It is with great pride that I, Randy Dorn, State Superintendent of Public Instruction officially adopt the revised K-12 Science Standards as the new essential academic learning requirements for the state of Washington.

Sincerely,

Randy Dorn

Randy I. Dorn
State Superintendent
of Public Instruction

Table of Contents

Washington State K-12 Science Standards

Overview

Purpose

The *Washington State K-12 Science Standards* is a detailed document describing what *all students* are expected to know and be able to do at each level of our educational system in the area of science. The purpose of these standards is to provide strong support for students, parents, teachers, and the broader community by guiding the alignment of the school curriculum, instruction, and assessment at local and state levels.

To accomplish this purpose it is essential to use this document in the following ways:

> Those responsible for **curriculum alignment** should refer to this document in selecting or developing instructional materials that enable students to acquire core conceptual knowledge and abilities in science.
>
> Those responsible for **assessment alignment** at the local and state levels should refer to this document in selecting and/or developing assessment tools and rubrics that measure student achievement of the core content in these standards.
>
> Those responsible for **instructional alignment** should refer to this document in designing classroom instruction and professional development of teachers to ensure that achieving these core content standards is a priority.

It is also important to point out what the standards are not intended to provide.

> *The standards do not prescribe teaching methods*. The standards do not specify preferred teaching methods or materials. The purpose of the standards is solely to enable content alignment of curriculum, assessment, and instruction by clearly specifying what students are to understand and be able to do—not to prescribe how teachers should help students learn.
>
> *The standards are not the curriculum.* The standards specify a core of conceptual knowledge and abilities that all students should achieve by the time they leave our classrooms. Many students will be able to go well beyond the basic content described in this document, which is recommended. Curriculum developers are encouraged to create science materials that are much richer in content and deeper in conceptual understanding than is specified on these pages.
>
> *The standards are not test specifications*. The standards describe what students should know and be able to do, and they constrain the content of statewide tests. But they do not specify how knowledge or abilities are to be assessed, either at the local or state levels.
>
> *The standards are not a checklist.* Aligning curriculum content and best instructional practice is not as simple as making sure topics in the curriculum match the standards. It is also necessary for teachers to assess whether or not their students are achieving standards, and to know how to teach effectively to all students.

This document includes both *content standards* and *performance expectations*.

Content standards, which appear in the left-hand column in the body of this document, describe what students should know and be able to do in science. Agreement on content standards was the first step in developing the *Washington State K-12 Science Standards*. Recognizing that many students will have the interests and abilities to go well beyond these standards, the content standards identify the most important concepts and abilities for expanding the scope of the curriculum to meet students' needs and interests.

Performance expectations, which appear in the right-hand column, provide clear guidance about the depth of knowledge expected at each grade band, and how students are expected to demonstrate their understanding and abilities on formative and summative measures. Performance expectations specify the floor—a minimum core of concepts and abilities to be achieved by all students.

Consistent with the *Washington State K-12 Mathematics Standards*, this document supports a vision of what *all students* should learn during science instruction in grades K-8, and at least three years of high school science. But these standards should not be used to limit science programs. Young children should have many experiences to spark and nurture their interests in science and technology, and high school students should have opportunities to take science courses that go well beyond these standards and help them with the next step in their education, whether at college, technical school, an apprenticeship program, or the world of work.

Essential Academic Learning Requirements

The 2009 version of the *Washington State K-12 Science Standards* strengthens the foundations of the previous document and incorporates the latest findings of educational research. The earlier document was based on three Essential Academic Learning Requirements (EALRs). In the new standards, EALRs 1, 2, and 3 describe crosscutting concepts and abilities that characterize the nature and practice of science and technology, while EALR 4 describes what all students should know and be able to do in the domains of Life, Physical, and Earth and Space Science.

EALR 1 **Systems** thinking makes it possible to analyze and understand complex phenomena. Systems concepts begin with the idea of the part-to-whole relationship in the earliest grades, adding the ideas of systems analysis in middle school and emergent properties, unanticipated consequences, and feedback loops in high school.

EALR 2 **Inquiry** is the bedrock of science and refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how the natural world works. Students ask and answer questions that facilitate growth in their understanding of the natural world. Inquiry includes the idea that an *investigation* refers to a variety of methods that can be used to answer a scientifically oriented question, including: systematic observations, field studies, models and simulations, open-ended explorations, and controlled experiments.

EALR 3 **Application** includes the ability to use the process of technological design to solve real-world problems, to understand the relationship between science and technology and their influence on society, and to become aware of the wide variety of careers in scientific and technical fields. These abilities are needed for people to apply what they learn in school to meet challenges in their own lives, to understand and help solve societal problems involving science and technology, and contribute to the prosperity of their community, state, and nation.

EALR 4 **The Domains of Science** focus on nine Big Ideas in the domains of Physical Science, Life Science, and Earth and Space Science that all students should fully understand before they graduate from high school so that they can participate and prosper as citizens in modern society.

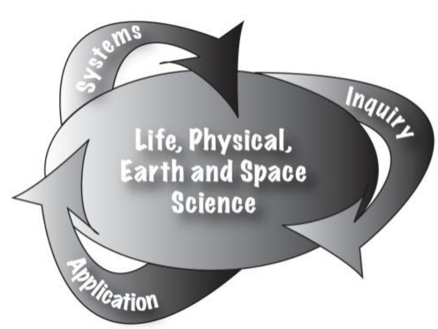
Although most state and national standards include the domains of science and scientific inquiry, and the application of science and technology to society, Washington is unique in emphasizing *systems*. ***Systems*** was chosen from among a list of unifying concepts and processes in the *National Science Education Standards* because of its growing importance in such diverse and cutting-edge fields as climate change, genetic engineering, and designing and troubleshooting complex technological systems. In addition to helping students understand and analyze scientific concepts and issues, systems thinking can help students address some of the challenges they encounter in everyday life as citizens, workers, and consumers.

Other unifying concepts and processes from the *National Science Education Standards* have also been woven into the *Washington State K-12 Science Standards*. For example, ***models*** are an important part of EALR 2 Inquiry. Students learn to design, build, and use models as well as recognize the limitations of models. The complementary processes of ***constancy*** and ***change*** are reflected throughout the standards, for example, in the conservation laws in physical science as well as the concept of dynamic equilibrium in ecosystems. Examples of ***directional, predictive***, and ***cyclic*** change are introduced and developed in the study of Earth systems, structures, and processes, and biological evolution.[i]

The EALRs of Systems, Inquiry, and Application are intended to be interwoven with core content in the science domains of Life, Physical, and Earth and Space Science. [ii] The purpose of this integration is to ensure students' long-term and conceptual understanding of the topic as well as improve their abilities to do science. For example, students might begin a field study by counting the number of organisms of two or three local species. Then they might look at a graph of owl and rodent populations in an area over a number of years, and discuss how patterns in the data might be interpreted in predator-prey relationships. The outcome of the lesson would include understanding of predator-prey relationships (Life Science) as well as the way those relationships can be investigated through field studies (Inquiry). Students might also discuss the ecosystem as a whole, and what might happen if the rodents or owls are impacted by disease (Systems), and what the trade-offs might be of different courses of action to protect the habitat (Application.)

No specific recommendations are given as to which science domains are best matched with Systems, Inquiry, and Application, and it is not expected that each science lesson would involve content from all three crosscutting areas. Decisions about how best to match the domains of science in EALR 4 with the crosscutting ideas in EALRs 1, 2, and 3 will be made at the school district level.

At the center of the Washington State science symbol are the domains of Life, Physical, and Earth and Space Science. The other three EALRs—Systems, Inquiry, and Application—are equally essential. They help students understand the science domains, and are in turn further developed as students apply them in all fields of science. The symbol emphasizes that scientific inquiry, systems thinking, and the application of science and technology should not be learned in isolation but rather in conjunction with the science domains.



Organization of the Standards

The *2009 Washington State K-12 Science Standards* differs from the previous standards document with respect to the grade bands and organization of the sciences.

Grade Bands. The most significant change is to extend standards in the domains of science from grade 10 to grade 11 in support of the recommendation[iii] that all students should take at least three years of high school science. Learning targets are specified in all science domains for a three-year science program, which could be met with a variety of different course structures and sequences. All students are encouraged to take a fourth year of science as well. Standards in Systems, Inquiry, and Application continue in grade 12 as crosscutting concepts and abilities, because they are integral to science learning and instruction.

It is essential for middle school students to have three full years of science to meet the middle school standards, to stimulate their interests in science, and to prepare them for a series of rigorous high school courses. The middle school grade band remains as a single three-year span for students in grades 6-8. A three-year grade band at the middle school level provides flexibility for school leaders to integrate the science program with other elements of the school curriculum.

The Science Standards Revision Team determined that the previous elementary grade bands were too broad because children develop rapidly in their cognitive abilities from kindergarten to 5th grade. Consequently, rather than two elementary grade bands, the new standards are presented in three grade bands at the elementary level, each spanning just two years. There is significant research to support two-year rather than three-year grade bands at the elementary level.[iv]

In summary, grade bands in the *K-12 Science Standards* are K-1, 2-3, 4-5, 6-8, and 9-12.

Big Ideas of Science. Another difference between these standards and the previous version is that content in the science disciplines is organized by nine Big Ideas in the major domains of science—three in Life Science, three in Earth and Space Science, and three in Physical Science. Each "Big Idea" is a single important concept that begins in the early grades, and builds toward an adult-level understanding.

The strategy of using Big Ideas to organize science standards arose in response to research showing that U.S. students lagged behind students in many other countries, at least in part because school curricula include far too many topics. According to the results of the Third International Mathematics and Science Study (TIMSS), "*Our curricula, textbooks, and teaching all are 'a mile wide and an inch deep.'*"[v]

A solution to this problem that has gained support from science education researchers in recent years is to organize science standards by a small number of "Big Ideas," which are essential for all people in modern society to understand.[vi] Organizing K-12 concepts and abilities by Big Ideas offers a way to decide what is and is not important for students to study, and provides a coherent vision of what students should know and be able to do that builds throughout a coherent K-12 science program.

In summary, the **content** of the *Washington State K-12 Science Standards* is organized according to twelve Big Ideas of Science: nine in the domains of Life, Physical, and Earth and Space Science, and three that cut across and unite all of the science domains: Systems, Inquiry, and Application.

Crosscutting Concepts and Abilities

Science is an active process that involves thinking in systems, asking and answering questions through *investigation*s, and applying science and technology to solve real-world problems. As illustrated in the chart below, these crosscutting concepts and abilities increase in complexity, depth, and range as students mature from one grade band to the next.

Cross-cutting	EALR 1 Systems	EALR 2 Inquiry	EALR 3 Application
The Big Ideas of Science	**…is a way of thinking that makes it possible to analyze and understand complex phenomena.**	**… is a process of asking and answering questions about the natural world that forms the bedrock of science.**	**…is about the interaction between science and technology, and how both can help solve real-world problems.**
Grades 9-12	**Predictability and Feedback**	**Conducting Analyses and Thinking Logically**	**Science, Technology, and Society**
	Create realistic models with feedback loops, and recognize that all models are limited in their predictive power.	Expand and refine skills and abilities of inquiry to gain a deeper understanding of natural phenomena.	Transfer and apply abilities in science and technological design to develop solutions to societal issues.
Grades 6-8	**Inputs, Outputs, Boundaries & Flows**	**Questioning and Investigating**	**Science, Technology, and Problem Solving**
	Look at a complex situation and see how it can be analyzed as a system with boundaries, inputs, outputs, and flows.	Investigate an answerable question through valid experimental techniques. Conclusions are based on evidence and are repeatable.	Work with other members of a team to apply the full process of technological design and relevant science concepts to solving a problem.
Grades 4-5	**Complex Systems**	**Planning *Investigation*s**	**Different Technologies**
	Analyze a system in terms of subsystems functions as well as inputs and outputs.	Plan different kinds of *investigation*s, including field studies, systematic observations, models, and controlled experiments.	Define technologies and the technological design process to understand the use of technology in different cultures and career fields.
Grades 2-3	**Role of Each Part in a System**	**Conducting *Investigation*s**	**Solving Problems**
	See how parts of objects, plants, and animals are connected and work together.	Carry out *investigation*s by using instruments, observing, recording, and drawing evidence-based conclusions.	Develop a solution to a problem by using a simplified technological design process. Investigate the use of tools.
Grades K-1	**Part-Whole Relationships**	**Making Observations**	**Tools and Materials**
	Identify parts of living and non-living systems.	Answer questions by explaining observations of the natural world.	Use simple tools and materials to solve problems in creative ways.

Big Ideas in EALR 4: The Domains of Science

The following tables summarize the nine big ideas in the science domains. Under each big idea are notes about how the learning in each of the grade level spans contributes to the development of the big idea as children advance through the grade levels. While these brief notes do not capture all of the concepts and abilities that students are expected to acquire, they do show how what students learn in any given year related to what they learned before and to what they will be expected to learn at the next grade band.[vii]

Science Domain	EALR 4 Physical Science		
The Big Ideas of Science	**Force and Motion** concerns the forces and motions that occur in our physical universe. At the highest level, students apply Newton's Laws of Motion and Gravity to explain phenomena such as the fall of a leaf and the motions of planet Earth in space.	**Matter: Properties and Change** concerns the fundamental nature of matter, including the atomic-molecular theory that explains macroscopic properties of materials and makes it possible to predict the outcomes of chemical and nuclear reactions.	**Energy: Transfer, Transformation, and Conservation** concerns energy as it changes forms and moves from one place to another. Energy is never created or destroyed. These concepts are useful in explaining phenomena in all domains.
Grades 9-11	**Newton's Laws**	**Chemical Reactions**	**Transformation and Conservation of Energy**
	Multiple forces affect an objects motion in predictable ways. These affects are explained by Newton's Laws.	Atomic structure accounts for atoms ability to combine to produce compounds. These changes maybe physical, chemical or nuclear.	Energy can take many forms and be transferred and transformed. Within a closed system the total energy is conserved.
Grades 6-8	**Balanced and Unbalanced Forces**	**Atoms and Molecules**	**Interactions of Energy and Matter**
	Objects in motion are affected by balanced and unbalanced forces. Speed and direction of motion change due to these forces.	Substances have unique properties based on their atomic structure. As atoms combine in a closed system their mass is conserved.	Energy and matter interact resulting in energy transfers and transformations. There are multiple forms of energy.
Grades 4-5	**Measurement of Force and Motion**	**States of Matter**	**Heat, Light, Sound, and Electricity**
	Forces and motions can be measured.	A single kind of matter can exist as a solid, liquid, or gas. Matter is conserved.	Heat, light, sound, and electrical energy can be transferred.
Grades 2-3	**Force Makes Things Move**	**Properties of Materials**	**Forms of Energy**
	Forces on objects make them move. Changes in forces will cause changes in the motion.	The properties of an object depend on its shape and on the material it is made from.	Energy comes in different forms.
Grades K-1	**Push-Pull and Position**	**Liquids and Solids**	
	Forces are pushes and pulls. Motion is a change in position.	Different kinds of materials display different properties.	

Science Domains	EALR 4 Earth and Space Science		
The Big Ideas of Science	**Earth and Space** is the longest and most comprehensive story that can be told, beginning with the birth of the universe and our home solar system, to the dynamic Earth-Sun-Moon system that set the stage for the wide diversity of life.	**Earth Systems, Structures, and Processes** includes the big picture of Earth as an interacting and dynamic system, including weather, and climate, the oceans, and the long-term movement of crustal plates that build up mountains and cause earthquakes, tsunami, and volcanoes.	**Earth History** has been uncovered by observing processes that take place today, and projecting those processes back in time. These remnants, especially fossils, provide essential clues to understanding the evolution of our planet.
Grades 9-11	**Evolution of the Universe**	**Energy in Earth Systems**	**Evolution of the Earth**
	Physical principles apply to the origins and development of the Earth and the Universe.	Energy from the Sun drives our weather system and climate, while energy from Earth's interior drives the rock cycle and crustal plates.	Evidence provided by natural radioactive material has made it possible to determine the age of different structures and of Earth as a planet.
Grades 6-8	**The Solar System**	**Cycles in Earth Systems**	**Evidence of Change**
	Our Solar System is held together by gravity. Moon phases and eclipses are explained.	Earth is an interacting system of solids, liquids, and gases. Important Earth processes include the water cycle and the rock cycle.	Layers of rocks and different types of fossils provide clues to how conditions on Earth have changed over time.
Grades 4-5	**Earth in Space**	**Formation of Earth Materials**	**Focus on Fossils**
	Earth is spherical in shape. It spins on its axis and orbits the Sun.	Earth materials are formed by various natural processes and can be used in different ways.	Fossils provide evidence that environments of the past were quite different from what we observe today.
Grades 2-3	**The Sun's Daily Motion**	**Water and Weather**	
	The Sun and Moon appear to have patterns of movement that can be inferred by observing and recording shadows cast by the Sun.	Water is essential in Earth systems. This is seen by observing and recording changes in weather patterns and Earth formations.	
Grades K-1	**Observing the Sun and Moon**	**Properties and Change**	
	The Sun and the Moon appear to have patterns of movement that can be observed and recorded.	Earth materials have various properties.	

Science Domains	EALR 4 Life Science		
The Big Ideas of Science	**Structure & Function of Living Systems** includes the way living things are organized and carry on life processes, from the components of a single cell to complex multicellular organisms such as humans.	**Ecosystems** are defined as all of the plant and animal populations and nonliving resources in a given area. The relationships between organisms within an ecosystem make it possible to predict the consequences of change and provide insights into the sustainable use of natural resources.	**Biological Evolution** is the essential framework for understanding how organisms change over time, from the first single-celled bacteria on the young Earth to the amazing diversity of species that populate our planet today. Evidence and reasoning are essential to recognize the patterns and scale of past changes.
Grades 9-11	**Processes Within Cells**	**Maintenance and Stability of Populations**	**Mechanisms of Evolution**
	Cells contain the mechanisms for life functions, reproduction, and inheritance.	A variety of factors can affect the ability of an ecosystem to maintain current population levels.	The underlying mechanisms of evolution include genetic variability, population growth, resource supply, and environment.
Grades 6-8	**From Cells to Organisms**	**Flow of Energy Through Ecosystems**	**Inheritance, Variation and Adaptation**
	Cell type and organization provide living systems structure and function.	Energy flows through ecosystems from a primary source through all living organisms.	Multiple lines of evidence support biological evolution. These include genetics, reproduction, adaptation and speciation.
Grades 4-5	**Structures and Behaviors**	**Food Webs**	**Heredity and Adaptation**
	Plants and animals have different structures that meet their needs and respond to the environment.	Changes in ecosystems affect the populations that can be supported in a food web.	Ecosystems change. Organisms that can adapt to these changes will survive and reproduce in higher numbers.
Grades 2-3	**Life Cycles**	**Changes in Ecosystems**	**Variation of Inherited Characteristics**
	Plants and animals have life cycles.	Changes in ecosystems affect living populations and the non-living elements of a defined area.	Plants and animals vary from one another and their parents. These differences serve as the basis for natural selection.
Grades K-1	**Plant and Animal Parts**	**Habitats**	**Classifying Plants and Animals**
	Plants and animals meet their needs in different ways.	Habitats are places that meet the daily needs of plants and animals.	Both plants and animals have different characteristics that can be used to classify them.

Fewer Topics—Greater Depth

Because grade bands at the elementary level span two years, teachers at this level are responsible for teaching just half of the standards in the science domains (EALR 4) specified for their grade band. Because the middle school grade band spans three years, middle school teachers are responsible for teaching one-third of the standards per year at that grade band. High school teachers are also responsible for just one-third of the standards in the science domains.

The recommendation that a standard be learned in depth during one year and not repeated every year is to avoid the "mile wide and inch deep"[v] problem that characterized science education in the past. The strategy that underpins the current standards is that by focusing on just a few concepts and skills each year, teachers will have time to ensure that all of their students will achieve mastery.

This strategy involves a trade-off in "spiraling," or returning to the same core content in subsequent years. Though these standards recommend against re-teaching the same concepts year after year, they do support the need to check students' understanding and abilities learned in prior years, and the need for occasional "refresher" activities to ensure that students' knowledge and abilities continue to grow.

But with regard to Systems, Inquiry, and Application (EALRs 1, 2, and 3), this document *does* support the strategy of teaching the concepts and abilities of systems, inquiry, and application *every year K-12*, but not as isolated topics. Rather, these ideas and capabilities, which also increase in complexity and power from year to year, are to be integrated with core content in the science domains.

For this strategy to work, it has been necessary to reduce the number of standards to a manageable level. Public comment on earlier drafts and the results of research[viii] have clearly indicated that standards must be manageable if teachers and students are to be held accountable and students are to reach their highest levels of learning. Consequently, the teams developing these standards have been thoughtful in setting priorities so that *all students* can succeed.

Criteria for Development of Standards

Development of Content Standards and Performance Expectations were based on the following criteria:

Essential. To keep the number of Standards manageable, only science content that is essential for understanding the Big Ideas of science has been included. Standards in adjacent grade bands that were similar have been eliminated. It is expected that the remaining standards will be learned in depth.

Clear. The science standards should not depend on scientific vocabulary alone to convey the meaning of a statement. Where scientific vocabulary is needed to convey meaning, the term is *italicized* and defined in context. Recognizing that a common term for one person may be a "scientific term" for another, we have also included a glossary for all *italicized* terms.

Specific. It is especially important that the Science Standards specify not only the content that students are expected to study but also the depth they are expected to achieve. The new standards describe what students should *know about* science, as well as the *abilities* they should acquire.

Rigorous. The level of rigor is based on appropriate grade-level placement of standards, so that learning expectations meet the developmental readiness of the students.

Relevant. The Science Standards also include content about personal health and environmental change from the *National Science Education Standards*[ix] so that science learning is relevant not only to the domains of science, but also to the needs of individuals and society.

Anatomy of a Standard

Although most people will refer to this entire document as "The Science Standards," it is important to recognize the function of each part of the explicit statements organized under grade-level bands. These are shown in the illustration below.

Standards for Grades K-1

EALR 4: Domains of Science (Life, Physical, or Earth and Space Science).

This is one of nine **Big Ideas** in the science domains.

EALR 4: **Earth and Space Science**
Big Idea: **Earth Systems, Structures, and Processes (ES2)**
Core Content: ***Earth Materials***

Students learn about Earth materials through their own observations. They learn to distinguish between natural materials and those processed by people. They study natural substances such as rocks and soil, and find that these Earth materials are made up of smaller parts and different kinds of materials. They learn to use common terms, such as hard, soft, dry, wet, heavy, and light, to describe what they see. These observations help students become familiar with the materials in the world around them and to begin thinking of properties of materials rather than objects.

Core Content Summary describes what students can be expected to know entering this grade band, what they will learn, and why it's important that they meet these content standards.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
K-1 ES2A	Some objects occur in nature; others have been designed and processed by people.	Sort objects into two groups: *natural* and *human-made*.*a
K-1 ES2B	Earth materials include solid rocks, sand, and soil; and water. These materials have different observable physical *properties*.	*Describe* Earth objects using appropriate terms, such as hard, soft, dry, wet, heavy, and light, to *describe* these materials. Sort Earth objects by one observable property (e.g., rocks by size or color).*a *Compare* Earth objects by at least two properties (e.g., first *compare* rocks by size, then by color). *a
K-1 ES2C	Some Earth objects are made of more than one material.	Observe and *describe* objects made of more than one Earth material (e.g., certain rocks and soil).

Content Standards describe what students should know and be able to do.

Performance Expectations specify depth of knowledge and evidence that students have met the standard.

Mathematics Connections

*a K.3.B Sort shapes, using a sorting rule, and explain the sorting rule.

Mathematics Connections are related statements from the WA Mathematics Standards.

Mathematics Connections

Many of the standards in the *Washington State K-12 Mathematics Standards* suggest concepts, procedures, or processes that complement and support standards in science. These connections have been identified as footnotes below each set of Content Standards. The mathematics ideas will be learned as part of mathematics instruction. Because the mathematics ideas will be learned at the same grade level or an earlier grade level as the science, students can use them as tools in science. One significant difference between the Mathematics and Science Standards is that the Mathematics Standards require students to use both metric and U.S. Customary units, while students in science will be expected only to use the metric system. We encourage mathematics and science teachers to collaborate on how best to ensure that students have acquired the necessary mathematics learning before, or at the same time the associated science Performance Expectations (PEs) are learned.

As illustrated by the increased number of references to the Mathematics Standards in middle and high school, the connection between science and mathematics grows closer as students take more advanced courses. Research on the relationship between high school courses and college success indicate that those who anticipate attending college or technical schools would do well to take four full-year courses in mathematics, as well as science courses in the fields that they intend to pursue at college.[x]

Conclusion

By providing an explicit statement of what *all students* should know and be able to do in science, this document plays an essential role in our state's educational system. By making it possible to align curriculum, instruction, and assessment, the *Washington State K-12 Science Standards* provides the clarity, specificity, and priorities that educators need to help every student be successful in science.

These standards also provide a starting point for a vision of science education that goes well beyond core standards. The Big Ideas in the science domains and crosscutting concepts and skills can serve as the base for an enriched science program at all levels in elementary and middle schools, and for the design of high school courses that address these and other concepts and abilities in innovative ways.

These science education standards provide a critical foundation, but much work remains to be done. In order to create a fully aligned science education system, we will also need to:

- Identify science curricula and instructional support materials that will enable teachers to help their students meet the standards.
- Develop formative assessments and other tools that complement the curriculum materials, which teachers can use to improve their capabilities to help their students meet these standards.
- Provide systematic professional development to increase teachers' knowledge of science, their abilities to use instructional materials with formative assessments effectively, and to teach in ways that support high student achievement.
- Align the State of Washington's standardized assessments of student learning with these standards, using performance expectations as common targets for curriculum, instruction, and assessment.
- Develop online availability of standards and resources in various forms and formats, with example classroom vignettes and assessment support.

Although the organization and many of the details have been changed, the essential content and spirit of these standards are very similar to our previous science standards. Consequently, these new standards are not a major change in the direction for science education in the state. But it will be important for educational leaders to fully understand these standards so that science education at a local level can target the highest-priority learning goals while meeting the needs of students for rich and deep science learning experiences.

Endnotes

[i] A more detailed description of K-12 unifying concepts and processes can be found in the *National Science Education Standards*, pages 115 to 119.

National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

[ii] A number of recent research syntheses have shown that scientific inquiry and content in the science domains must be learned together. For example: "To develop competency in the area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application." (Bransford et. al., page 16)

Bransford, J.D., Brown, A.L., Cocking, R.R. (2000). *How people learn: Brain, mind, experience and school,* expanded edition. Washington, DC: National Academy Press.

[iii] These standards support a recommendation by the Washington State Board of Education that all students should take three years of high school science, under a broad proposal for high school graduation requirements known as Core 24.

[iv] The period between kindergarten and 5th grade is marked by rapid growth in children's abilities to learn new concepts and skills. Although all children do not mature at the same rate, most groups of 5th-graders can begin to learn more complex ideas and abilities than second-graders, who in turn can handle more complex content than kindergartners. That is why we have divided the elementary levels into three grade bands rather than two. Researchers have taken different approaches to explaining how and why cognitive development occurs rapidly during the elementary years. One explanation is that working memory (the number of pieces of information that a child can handle at the same time) expands rapidly during the elementary years, determining the complexity of tasks that a child can successfully undertake. Also important is the domain-specific knowledge that students acquire through in-school and informal learning experiences, as well as general thinking and problem-solving abilities (Flavell, 2002, Chapters 1, 4, and 7). A recent summary of research on children's learning in science in grades K-8 conducted by the National Research Council states, "What children are capable of at a particular age is the result of a complex interplay among maturation, experience, and instruction. What is developmentally appropriate is not a simple function of age or grade, but rather is largely contingent on their prior opportunities to learn" (Duschl et. al., 2007, page 2). Therefore, the *Washington State K-12 Science Standards* has made it as clear as possible what "opportunity to learn" means for each grade span, with respect to concepts within the domains of science and the broadly transferable capabilities of systems thinking, inquiry, and application.

Flavell, J.H. (2002). *Cognitive development,* 4th edition. Upper Saddle River, NJ: Prentice-Hall, Inc.

Duschl, R.A., Schweingruber, H.A., and Shouse, A.W., Editors (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: National Academy Press.

[v] Schmidt, W., McKnight, C., and Raizen, S. (1997). *A splintered vision: An investigation of U.S. science and mathematics education, executive summary*, U.S. National Research Center for the Third International Mathematics and Science Study, Michigan State University. Available on the web at: ustimss.msu.edu/splintrd.pdf.

[vi] Michaels, S., Shouse, A.W., and Schweingruber, H.A. (2008). Chapter four: Organizing science education around core concepts, in *Ready, Set, Science!: Putting research to work in K-8 science classrooms.* Washington, D.C.: National Academy Press.

[vii] The Science Standards Revision Team based their decisions about the most appropriate grade levels for introducing concepts on available research syntheses. The *Atlas for Science Literacy, Volumes 1 and 2* (Project 2061, 2001, 2007) were very helpful, as were other sources such as learning progression reviews (Smith, et. al., 2006).

Project 2061, American Association for the Advancement of Science (AAAS 2001, 2007). *Atlas for science literacy,* volumes 1 and 2. Washington, DC: AAAS and the National Science Teachers Association, co-publishers.

Smith, C.L., Wiser, M., Anderson, C.W., Krajcik, J. (2006). Implications of research on children's learning for standards and assessment: A proposed learning progression for matter and the atomic molecular theory. *Measurement: Interdisciplinary Research and Perspectives,* 14, 1-98.

[viii] Li, J., Klahr, D., and Siler, S. (2006). What lies beneath the science achievement gap: The challenges of aligning science instruction with standards and tests. *Science Educator*, Vol. 15, No. 1, pp. 1-12.

[ix] National Research Council (1996). *National science education standards.* Washington, DC: National Academy Press.

[x] Sadler, P.M., and Tai, R.H. (2007). The two high-school pillars supporting college science. *Science* Vol. 317, No. 5837, pp. 457-458.

Science Standards
Grades K-1

The science standards for grades K-1 consist of seven Core Content Standards within the domains of science. These standards should be learned during the two-year grade span, so that only three or four of them need to be learned ***in depth*** each year. Local school district curriculum teams will decide which of the areas will be learned at which grade level, depending on students' needs and interests.

As illustrated by the grid below, the three crosscutting EALRs (1-3) of Systems, Inquiry, and Application are not to be learned in isolation but rather in conjunction with content in the (EALR 4) domains of science. Not every topic needs to address all three crosscutting EALRs. But in any given year, content in (EALRs 1-3) Systems, Inquiry, and Application should be experienced in the context of several science lessons, so that students can see the commonalities among the fields of science.

Grades K-1 **EALR 4 Domains of Science**	**EALR 1** **Systems** **SYS**	**EALR 2** **Inquiry** **INQ**	**EALR 3** **Application** **APP**
Physical Science PS1 Push-Pull and Position PS2 Liquids and Solids **Earth and Space Science** ES1 Observing the Sun and Moon ES2 Properties and Change **Life Science** LS1 Plant and Animal Parts LS2 Habitats LS3 Classifying Plants and Animals	Part-Whole Relationships	Making Observations	Tools and Materials

EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Part-Whole Relationships***

In grades K-1, students gain fluency in using the concept of part-whole relationships. They agree on names for the parts that make up several types of whole objects, including plants and animals. They learn that objects can be easily taken apart and put back together again, while other objects cannot be taken apart and reassembled without damaging them. Removing one or more parts will usually change how the object functions. Fluency with the part-whole relationship is essential for all of the sciences and is an important building block for more sophisticated understanding of how systems operate in natural and designed environments.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 SYSA	Living and nonliving things are made of parts. People give names to the parts that are different from the name of the whole object, plant, or animal.	• Name at least five different parts, given an illustration of a whole object, plant, or animal. • *Compare* a part of an object with the whole object, correctly using the words "whole" and "part."
K-1 SYSB	Some objects can easily be taken apart and put back together again while other objects cannot be taken apart without damaging them (e.g., books, pencils, plants, and animals).	• Identify which of several *common* objects may be taken apart and put back together without damaging them (e.g., a jigsaw puzzle) and which objects cannot be taken apart without damaging them (e.g., books, pencils, plants, and animals). *a

Mathematics Connections

*a 1.3.C Combine known shapes to create shapes and divide known shapes into other shapes.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Making Observations***

Students learn that scientific investigations involve trying to answer questions by making observations or trying things out, rather than just asking an adult. Children are naturally curious about nearly everything—butterflies and clouds, and why the Moon seems to follow them at night. The essence of this standard is to channel students' natural curiosity about the world, so that they become better questioners, observers, and thinkers, laying the groundwork for increasing understanding and abilities in science inquiry in the years to come.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 INQA Question and Investigate	Scientific *investigation*s involve asking and trying to answer a *question* about the *natural world* by making and recording *observations.*	• Ask *questions* about objects, *organisms*, and events in their *environment.**a • Follow up a *question* by looking for an answer through students' own activities (e.g., making *observations* or trying things out) rather than only asking an adult to answer the *question.* • Observe patterns and *relationships* in the *natural world,* and record *observations* in a table or picture graph.*b
K-1 INQB Model	Many children's toys are *models* that represent real things in some ways but not in other ways.	• Given a child's toy that is a *model* of an object found in the real world, *explain how* it is like and unlike the object it represents.
K-1 INQC Explain and Infer	Scientists develop explanations using recorded *observations* (*evidence*).	• *Describe patterns* of data recorded, using tallies, tables, picture graphs, or bar-type graphs.*c • Participate in a discussion of how the recorded data *(evidence)* might help to *explain* the *observations.*
K-1 INQD Communicate	Scientists report on their *investigation*s to other scientists, using drawings and words.	• Report *observations* of simple *investigation*s, using drawings and simple sentences. • Listen to and use *observations (evidence)* made by other students.
K-1 INQE Communicate	*Observations* are more reliable if repeated, especially if repeated by different people.	• State verbally or in writing a need to repeat *observations (evidence)* to be certain the results are more *reliable.*
K-1 INQF Intellectual Honesty	All scientific *observations* must be reported honestly and accurately.	• Record *observations (evidence)* honestly and accurately.

Mathematics Connections

*a	K.5.A, 1.6.A	Identify the question(s) asked in a problem.
*b	1.5.A	Represent data using tallies, tables, picture graphs, and bar-type graphs.
*c	1.5.B	Ask and answer comparison questions about data.

EALR 3: **Application**

Big Idea: **Application (APP)**

Core Content: ***Tools and Materials***

Students learn to use simple tools (e.g., pencils, scissors) and materials (e.g., paper, tape, glue, and cardboard) to solve problems in creative ways. Though students have a natural inclination to use tools and materials to make things, guidance is required to channel these interests into solving a practical problem. Although students are not expected to make a distinction between science and technology at this age, they can and should develop the idea that tools and materials can be used to solve problems, and that many problems can have more than one solution.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 APPA	*Common tools* can be used to solve problems.	• Use simple *tools* and materials to solve a simple problem (e.g., make a paper or cardboard box to hold seeds so they won't get lost).*a
K-1 APPB	Different materials are more suitable for some purposes than for other purposes.	• Choose a material to meet a specific need (e.g., cardboard is better than paper for making a box that will stand up by itself) and *explain* why that material was chosen. *a
K-1 APPC	A problem may have more than one acceptable *solution*.	• Develop two possible *solutions* to solve a simple problem (e.g., *design* a napping place for a favorite stuffed animal; decide on the best food to eat for lunch).*b
K-1 APPD	Counting, classifying, and measuring can sometimes be helpful in solving a problem.	• *Apply* the abilities of counting, measuring, and classifying to solving a problem (e.g., Is that enclosure big enough for a pet to stand up in? What types of food can it eat? How much food should I put into the enclosure for my pet?).*c

Mathematics Connections

*a	K.5.D, 1.6.D	Select from a variety of problem-solving strategies and use one or more strategies to solve a problem.
*b	K.5.F, 1.6.G	Describe how a problem was solved.
*c	K.1.E	Count objects in a set of up to 20, and count out a specific number of up to 20 objects from a larger set.
	1.1.A	Count by ones forward and backward from 1 to 120, starting at any number, and count by twos, fives, and tens to 100.
	K.4.A	Make direct comparisons, using measurable attributes such as length, weight, and capacity.
	1.4.B	Use a variety of nonstandard units to measure length.

Note: This standard is closely aligned to Core Processes K.5 and 1.6

EALR 4: **Physical Science**

Big Idea: **Force and Motion (PS1)**

Core Content: ***Push-Pull and Position***

Students learn how to describe the position and motion of objects and the effects of forces on objects. Students start by describing the position of one object with respect to another object (e.g., in front, behind, above, and below) and then describe motion as a change in position. Forces are introduced as pushes and pulls that can change the motion of objects, and students learn through observation that various forces act through contact while others act from a distance (without touching the object). These basic concepts about forces and motion provide a foundation for learning to quantify motion in later years.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 PS1A	The position of an object can be *described* by locating it relative to another object or to the object's surroundings.	• Use *common* terms so that all observers can agree on the position of an object in relation to another object (e.g., *describe* whether the teacher's desk is in front of the room, at the side, or in the back; say whether the top of the school's flagpole is higher or lower than the roof).*a
K-1 PS1B	*Motion* is defined as a change in position over time.	• Demonstrate *motion* by moving an object or a part of a student's body and *explain that motion* means a change in position.
K-1 PS1C	A *force* is a push or a pull. Pushing or pulling can move an object. The *speed* an object moves is related to how strongly it is pushed or pulled.	• Respond to a request to move an object (e.g., toy wagon, doll, or book) by pushing or pulling it. • When asked to move the object farther, respond by pushing or pulling it more strongly. • *Explain that* a push or a pull is a *force*.
K-1 PS1D	Some *forces* act by touching and other *forces* can act without touching.	• Distinguish a *force* that acts by touching it with an object (e.g., by pushing or pulling) from a *force* that can act without touching (e.g., the attraction between a magnet and a steel paper clip).

Mathematics Connections

***a** K.3.C Describe the location of one object relative to another using words such as in, out, over, under, above, below, between, next to, behind, and in front of.

EALR 4: **Physical Science**

Big Idea: **Matter: Properties and Change (PS2)**

Core Content: ***Liquids and Solids***

Students learn about the properties of liquids and solids. When a liquid is poured into a container, it takes the shape of the part of the container that it occupies. Cooling a liquid can turn the liquid into a solid (e.g., water to ice). When it becomes a solid it assumes the shape of the container and retains that shape, even when removed from the container. These observations about the properties of materials and how numerous materials can change from liquid to solid and back again begin to build an understanding of matter and its transformations that will be formalized as states of matter during the grade 2-3 band.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 PS2A	*Liquids* take the shape of the part of the container they occupy.	• *Predict* the shape that water will take in a variety of different containers.
K-1 PS2B	*Solids* retain their shape regardless of the container they are in.	• *Predict* that frozen water (e.g., ice) will retain its shape when moved among containers of different shapes (e.g., ice cubes in a tray). • Given several substances, sort them into those that are *liquid* and those that are *solid.*

EALR 4: **Physical Science**

Big Idea: **Energy: Transfer, Transformation and Conservation (PS3)**

Core Content: ***None***

No standards for K-1 Energy: Transfer, Transformation and Conservation because the content is not developmentally appropriate for students in this grade band.

EALR 4: **Earth and Space Science**

Big Idea: **Earth in Space (ES1)**

Core Content: ***Observing the Sun and Moon***

Students learn that objects they see in the sky, such as clouds and birds, change from minute to minute, while other things, such as apparent movement of the Sun and Moon, follow patterns if observed carefully over time. The Moon can sometimes be seen during the day and sometimes at night, and its shape appears to change gradually during the month. The study of the sky can help young children realize that they can find patterns in the world through their own observations.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 ES1A	Many things can be seen in the sky. Some change minute by minute, while others move in *patterns* that can be seen if they are observed day after day.	• Observe and *communicate* the many things that can be seen in the sky that change minute by minute (e.g., birds, airplanes, and clouds) and those that change their shape or position in observable *patterns* day after day (e.g., apparent shape of the *moon*).*a
K-1 ES1B	The position of the Sun in the sky appears to change during the day.	• *Compare* the position of the Sun in the sky in the morning with its position in the sky at midday and in the afternoon.*b
K-1 ES1C	The *Moon* can be seen sometimes during the day and sometimes during the night. The *Moon* appears to have different shapes on different days.	• Observe the *Moon* during different times of the day and month, and draw its apparent shape.*b

Mathematics Connections

*a	K.4.A	Make direct comparisons, using measurable attributes such as length, weight, and capacity.
*b	K.3.C	Describe the location of one object relative to another using words such as in, out, over, under, above, below, between, next to, behind, and in front of.

EALR 4: **Earth and Space Science**

Big Idea: **Earth Systems, Structures and Processes (ES2)**

Core Content: ***Properties and Change***

Students learn about Earth materials through their own observations. They learn to distinguish between natural materials and those that have been changed by people. They study natural substances such as rocks and soil, and find that these Earth materials are made up of smaller parts and different components. They learn to use common terms, such as hard, soft, dry, wet, heavy, and light, to describe what they see. These observations help students become familiar with the materials in the world around them in terms of properties and to think about how people use natural materials in various ways.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 ES2A	Some objects occur in nature; others have been *designed* and processed by people.	• Sort objects into two groups: natural and *human-made*.*a
K-1 ES2B	Earth materials include *solid* rocks, sand, soil, and water. These materials have different observable physical *properties*.	• *Describe* Earth objects using appropriate terms, such as hard, soft, dry, wet, heavy, and light, to *describe* these materials. • Sort Earth objects by one observable property (e.g., rocks by size or color).*a • *Compare* Earth objects by at least two *properties* (e.g., first *compare* rocks by size, then by color). *a
K-1 ES2C	Some Earth objects are made of more than one material.	• Observe and *describe* objects made of more than one Earth material (e.g., certain rocks and soil).

Mathematics Connections

*a	K.3.B	Sort shapes, using a sorting rule, and explain the sorting rule.

EALR 4: **Earth and Space Science**

Big Idea: **Earth History (ES3)**

Core Content: ***None***

No standards for K-1 Earth History because the content is not developmentally appropriate for students in this grade band.

EALR 4: **Life Science**

Big Idea: **Structures and Functions of Living Organisms (LS1)**

Core Content: ***Plant and Animal Parts***

Students learn that all living things have basic needs, and they meet those needs in various ways. Just as humans have external body parts that perform different functions to meet their needs, animals and plants also have body parts that perform different functions to meet their needs. A magnifier is a tool that reveals further details of plant and animal parts that are not easily seen with the unaided eye. Learning about the diverse needs of plants and animals and the various ways they meet their needs will help to prepare students to understand more detailed structures beginning at the 2-3 grade band.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 LS1A	The human body is made up of various external parts.	• Identify the external parts of a human body (e.g., head, hands, feet, knees, and elbows).
K-1 LS1B	All plants and animals have various external parts.	• Identify the external parts of different plants and animals (e.g., legs on an insect, flowers, stems, and roots on many plants, feathers on birds, scales on fish, eyes and ears on many animals).
K-1 LS1C	The parts of a plant or animal appear different under a *magnifier compare*d with the unaided eye.	• Observe how parts of a plant or animal look under a *magnifier* and draw or use words to *describe* them (e.g., a single hair, the leg of an insect, a fingerprint).
K-1 LS1D	Different animals use their body parts in different ways to see, hear, grasp objects, and move from place to place.	• *Compare* how different animals use the same body parts for different purposes (e.g., humans use their tongues to taste, while snakes use their tongues to smell).
K-1 LS1E	Animals have various ways of obtaining food and water. Nearly all animals drink water or eat foods that contain water.	• *Compare* how different animals obtain food and water (e.g., a squirrel hunts for nuts, a pet dog eats prepared food and drinks water from a bowl or puddle, many birds and insects find nectar in flowers, which contain food and water, people may grow food in gardens and many shop for food in stores and get water from the tap).
K-1 LS1F	Most plants have roots to get water and leaves to gather sunlight.	• *Explain* that most plants get water from soil through their roots and that they gather light through their leaves.

EALR 4: **Life Science**

Big Idea: **Ecosystems (LS2)**

Core Content: ***Habitats***

Students learn that all plants and animals live in and depend on habitats. Earth has many different habitats, and these different habitats support the life of many different plants and animals, including humans. People have the ability to make rapid changes in natural habitats and to keep a habitat healthy so that living conditions can be maintained.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 LS2A	There are different kinds of natural areas, or *habitats*, where many different plants and animals live together.	• *Investigate* an area near their home or school where many different plants and animals live together (e.g., a lawn, a vacant lot, a wooded park, a flower bed) and *describe* the different plants and animals found there.
K-1 LS2B	A *habitat* supports the growth of many different plants and animals by meeting their basic needs of food, water, and shelter.	• Identify the *characteristics* of a *habitat* that enable the *habitat* to support the growth of many different plants and animals (e.g., have trees to provide nesting places for birds and squirrels, pond water for tadpoles and frogs, blackberry bushes for rabbits to hide in).
K-1 LS2C	Humans can change natural *habitats* in ways that can be helpful or harmful for the plants and animals that live there.	• List two or more things that humans do that might harm plants and animals in a given *habitat* (e.g., throwing litter in a pond might cause difficulty for water birds and fish to find food or might poison the plants and animals that live there). • Communicate ways that humans protect *habitats* and/or improve conditions for the growth of the plants and animals that live there (e.g., reuse or recycle products to avoid littering).

EALR 4: **Life Science**

Big Idea: **Biological Evolution (LS3)**

Core Content: ***Classifying Plants and Animals***

Students learn that some objects are alive and others are not, and that many living things are classified as either plants or animals based on observable features and behaviors. Plants and animals are further classified into smaller groups such as insects and trees. Even these groups can be further subdivided. Classification provides a way to organize and find patterns in the amazing diversity of plants, animals, and the nonliving environment.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
K-1 LS3A	Some things are alive and others are not.	• Use logical rules to sort objects into two groups, those that are alive and those that are not.*a
K-1 LS3B	There are many different types of living things on Earth. Many of them are classified as plants or animals.	• Given a list, illustrations, or actual plants or animals, *classify* them as plants or animals.
K-1 LS3C	External features of animals and plants are used to *classify* them into groups.	• *Describe* several external features and behaviors of animals that can be used to *classify* them (e.g., size, color, shape of body parts). • *Describe* several external features of plants that can be used to *classify* them (e.g., size, color, kinds of seeds, shapes, or texture of plant parts). • Give examples to illustrate how pairs of plants and/or animals are similar to and different from each other (e.g., cats and dogs both have four legs, but many dogs have longer snouts than cats).*b

Mathematics Connections

*a	K.3.B	Sort shapes, using a sorting rule, and explain the sorting rule.
*b	K.4.A	Make direct comparisons, using measurable attributes such as length, weight, and capacity.

Science Standards
Grades 2-3

The science standards for grades 2-3 consist of eight Core Content Standards within the domains of science. These standards should be learned during the two-year grade span, so that only four of them need to be learned ***in depth*** each year. Local school district curriculum teams will decide which of the areas will be learned at which grade level, depending on students' needs and interests.

As illustrated by the grid below, the three crosscutting EALRs of Systems, Inquiry, and Application are not to be learned in isolation, but rather in conjunction with content in the science domains. Not every topic needs to address all three crosscutting EALRs. But in any given year, content in Systems, Inquiry, and Application should be experienced in the context of several science lessons so that students can see the commonalities among the fields of science.

Grades 2-3 **EALR 4 Domains of Science**	**EALR 1** **Systems** **SYS**	**EALR 2** **Inquiry** **INQ**	**EALR 3** **Application** **APP**
Physical Science PS1 Force Makes Things Move PS2 Properties of Materials PS3 Forms of Energy **Earth and Space Science** ES1 The Sun's Daily Motion ES2 Water and Weather **Life Science** LS1 Life Cycles LS2 Changes in Ecosystems LS3 Variation of Inherited Characteristics	Role of Each Part in a System	Conducting Investigations	Solving Problems

EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Role of Each Part in a System***

In prior grades students learned to recognize part-whole relationships. In grades 2-3 students learn to think systematically about how the parts of objects, plants, and animals are connected and work together. They realize that the whole object, plant, or animal has properties that are different from the properties of its parts, and that if one or more parts are removed, the whole system may not continue functioning the same way. Students also note cases in which the same part may play a different role in a different system. Finally, they learn to define system as "a group of interacting parts that form a whole." Understanding that an object, plant, or animal is more than the sum of its parts is a deep insight that has value in investigating all natural and human-made systems.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 SYSA	A *system* is a group of interacting parts that *form* a whole.	• Give examples of simple living and physical *systems* (e.g., a whole animal or plant, a car, a doll, a table and chair set). For each example, *explain how* different parts make up the whole.
2-3 SYSB	A whole object, plant, or animal may not continue to *function* the same way if some of its parts are missing.	• *Predict* what may happen to an object, plant, or animal if one or more of its parts are removed (e.g., a tricycle cannot be ridden if its wheels are removed).*a • *Explain how* the parts of a *system* depend on one another for the *system* to *function.*
2-3 SYSC	A whole object, plant, or animal can do things that none of its parts can do by themselves.	• *Contrast* the *function* of a whole object, plant, or animal with the *function* of one of its parts (e.g., an airplane can fly, but wings and propeller alone cannot; plants can grow, but stems and flowers alone cannot).
2-3 SYSD	Some objects need to have their parts connected in a certain way if they are to *function* as a whole.	• *Explain* why the parts in a *system* need to be connected in a specific way for the *system* to *function* as a whole (e.g., batteries must be inserted correctly in a flashlight if it is to produce light).
2-3 SYSE	Similar parts may play different roles in different objects, plants, or animals.	• Identify ways that similar parts can play different roles in different *systems* (e.g., birds may use their beaks to crack seeds while other birds use their beaks to catch fish).

Mathematics Connections

*a 3.6.J Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Conducting Investigations***

In prior grades students learned that scientific investigations involve trying to answer questions by making observations or trying things out. In grades 2-3 students learn to conduct different kinds of investigations. Although students may not yet be able to plan investigations alone, they can carry out investigations in collaboration with other students and support from the teacher. Actions may include observing and describing objects, events, and organisms, classifying them and making and recording measurements. Students should also display their data using various tables and graphs, make inferences based on evidence, and discuss their results with other students.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 INQA Question	Scientific *investigation*s are *designed* to gain knowledge about the *natural world*.	• *Explain how observations* can lead to new knowledge and new *questions* about the *natural world*.*a
2-3 INQB Investigate	A scientific *investigation* may include making and following a plan to accurately observe and *describe* objects, events, and *organisms*; make and record measurements, and *predict* outcomes.	• Work with other students to make and follow a plan to carry out a scientific *investigation*. Actions may include accurately observing and describing objects, events, and *organisms*; measuring and recording data; and predicting outcomes.*b
2-3 INQC Infer	*Inferences* are based on *observations*.	• Distinguish between direct *observations* and simple *inferences*.
2-3 INQD Investigate	Simple instruments, such as *magnifiers*, *thermometers*, and rulers provide more information than scientists can obtain using only their unaided senses.	• Use simple instruments (e.g., metric scales or balances, *thermometers*, and rulers) to observe and make measurements, and record and display data in a table, bar graph, line plot, or pictograph.*c
2-3 INQE Model	*Models* are useful for understanding *systems* that are too big, too small, or too dangerous to study directly.	• Use a simple *model* to study a *system*. *Explain how* the *model* can be used to understand the *system*.
2-3 INQF Explain	Scientists develop explanations, using *observations* (*evidence*) and what they already know about the world. Explanations should be based on *evidence* from *investigation*s.	• Accurately *describe* results, referring to the graph or other data as *evidence*. Draw a *conclusion* about the *question* that motivated the study using the results of the *investigation* as *evidence*.*d
2-3 INQG Communicate Intellectual Honesty	Scientists make the results of their *investigation*s public, even when the results contradict their expectations.	• *Communicate* honestly about their *investigation*s, describing how *observations* were made and summarizing results.*d

Mathematics Connections

*a	2.5.A	Identify the question(s) asked in a problem and any other questions that need to be answered to solve the problem.
	3.6.A	Determine the question(s) to be answered, given a problem situation.
*b	2.3.C	Measure length to the nearest whole unit in both metric and U.S. customary units.
	3.5.B	Measure temperature in degrees Fahrenheit and degrees Celsius using a thermometer.
	3.5.C	Estimate, measure, and *compare* weight and mass, using appropriate-size U.S. customary and metric units.
*c	3.5.E	Construct and analyze pictographs, frequency tables, line plots, and bar graphs.
*d	3.6.I	Summarize mathematical information, draw conclusions, and explain reasoning.
	3.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 3: **Application**
Big Idea: **Application (APP)**
Core Content: ***Solving Problems***

In earlier grades, students learned to use simple tools and materials to solve problems in creative ways. In grades 2-3 students develop the ability to design a solution to a simple problem, using an elementary version of the technological design process. They also increase their abilities to use tools and materials to design and build something that solves a problem. Students can apply these abilities in their daily lives.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 APPA	Simple problems can be solved through a *technological design process* that includes: defining the problem, gathering information, exploring ideas, making a plan, testing possible *solutions* to see which is best, and communicating the results.	• *Design* a *solution* to a simple problem (e.g., *design* a *tool* for removing an object from a jar when your hand doesn't fit) using a *technological design process* that includes: defining the problem, gathering information, exploring ideas, making a plan, testing possible *solutions* to see which is best, and communicating the results. *a
2-3 APPB	Scientific ideas and discoveries can be applied to solving problems.	• Give an example in which the application of scientific knowledge helps solve a problem (e.g., use electric lights to see at night). *b
2-3 APPC	People in all *cultures* around the world have always had problems and invented *tools* and techniques (ways of doing something) to solve problems.	• *Describe* a problem that people in different *cultures* around the world have had to solve and the various ways they have gone about solving that problem.*a
2-3APPD	*Tools* help scientists see more, measure more accurately, and do things that they could not otherwise accomplish.	• Select appropriate *tools* and materials to meet a goal or solve a specific problem (e.g., build the tallest tower with wooden blocks or the longest bridge span) and *explain* the reason for those choices.
2-3 APPE	Successful *solutions* to problems often depend on selection of the best *tools* and materials and on previous experience.	• *Evaluate* how well a selected tool solved a problem and discuss what might be done differently to solve a similar problem.*b,c

Mathematics Connections

*a	3.6.F	Represent a problem situation, using words, numbers, pictures, physical objects, or symbols.
*b	2.5.G	Determine whether a solution to a problem is reasonable.
*c	2.5.D	Select from a variety of problem-solving strategies and use one or more strategies to solve a problem.
	3.6.E	Select and use one or more appropriate strategies to solve a problem.

Note: This standard is closely aligned to Core Processes 2.5 and 3.6

EALR 4: **Physical Science**

Big Idea: **Force and Motion (PS1)**

Core Content: ***Force Makes Things Move***

In prior grades students learned to use appropriate words to describe the position and motion of objects and the effects of forces on objects. In grades 2-3 students learn that forces work not only to push and pull objects, but also affect objects when they are dropped or thrown. Whenever the motion of an object changes, there is a force involved. Greater forces on a given object result in greater changes of motion. In addition to being able to describe how forces change the motion of objects, students are expected to measure the position of objects using measuring instruments such as rulers. Students can also measure time to the nearest minute. Emphasis should be on comparisons of forces and motions rather than on calculation so that students develop conceptual understanding of how forces make things move.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 PS1A	*Motion* can be *described* as a change in position over a period of time.	• Give an example to illustrate *motion* as a change in position over a period of time (e.g., if a student stands near the door and then moves to his/her seat, the student is "in *motion*" during that time).*a
2-3 PS1B	There is always a *force* involved when something starts moving or changes its *speed* or direction of *motion.*	• Identify the *force* that starts something moving or changes its *speed* or direction of *motion* (e.g., when a ball is thrown or when a rock is dropped).
2-3 PS1C	A greater *force* can make an object move faster and farther.	• Give examples to illustrate that a greater *force* can make an object move faster than a lesser *force* (e.g., throwing a ball harder or hitting it harder with a bat will make the ball go faster).
2-3 PS1D	The relative strength of two *forces* can be *compare*d by observing the difference in how they move a *common* object.	• Measure and *compare* the distances moved by an object (e.g., a toy car) when given a small push and when given a big push.*b

Mathematics Connections

*a	2.3.E	Use both analog and digital clocks to tell time to the minute.
*b	2.3.C	Measure length to the nearest whole unit in both metric and U.S. customary units.

EALR 4: **Physical Science**

Big Idea: **Matter: Properties and Change (PS2)**

Core Content: ***Properties of Materials***

In prior grades students learned about liquids and solids. In grades 2-3 students learn to identify different physical properties of materials (matter) and to realize that an object may be made from several different types of materials. They also learn that properties of materials change when environmental conditions change. Water, for example, changes to a solid when the temperature drops below 0°Celsius. Although few students at this age will fully understand that water may change to an invisible gas (e.g., water vapor) when left in an open container overnight, they can start to become familiar with changes of state by observing ice cubes freeze and then melt, and seeing water turn to steam when heated. Looking closely at matter to describe its characteristics will eventually lead to understanding the basic nature of matter and its physical and chemical properties.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 PS2A	Objects have *properties*, including size, *weight*, hardness, color, shape, texture, and magnetism. Unknown substances can sometimes be identified by their *properties*.	• List several *properties* of an object. • Select one of several objects that best matches a list of *properties*. • Sort objects by their *functions*, shapes, and the materials they are composed of.
2-3 PS2B	An object may be made from different materials. These materials give the object certain *properties.*	• List *properties* of *common* materials. • *Compare* similar objects made of different materials (e.g., a plastic spoon and a metal spoon) and *explain how* their *properties* are similar and different. • *Compare* two objects made of the same material but a different shape (e.g., a plastic fork and a plastic spoon) and identify which of their *properties* are similar and different.
2-3 PS2C	Water changes state (*solid*, *liquid*, *gas*) when the *temperature* of the water changes.	• *Predict* what will happen to a sample of *liquid* water if it is put into a freezer (it will turn to ice) and if it is put into a pan and heated on the stove (it will turn to *steam* or *water vapor*).*a
2-3 PS2D	The amount of water and other *liquids* left in an open container will decrease over time, but the amount of *liquid* in a closed container will not change.	• *Predict* what will happen to a small quantity of water left in an open container overnight. • *Predict* what will happen to the same quantity of water left in a closed container overnight. • *Explain* where the *liquid* water goes when the amount decreases over time. *a

Mathematics Connections

*a 3.6.J Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 4: **Physical Science**

Big Idea: **Energy: Transfer, Transformation, and Conservation (PS3)**

Core Content: ***Forms of Energy***

Students learn to identify several different forms of energy. Children in this age range have an intuitive understanding of energy concepts. For example, energy is needed to get things done; humans get energy from food. It is possible to build on these ideas by having the students explore different energy phenomena.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 PS3A	*Heat*, light, *motion*, electricity, and sound are all forms of *energy*.	• Use the word *energy* to *explain* everyday activities (e.g., food gives people *energy* to play games). • Give examples of different forms of *energy* as observed in everyday life: light, sound, and *motion*. • *Explain how* light, sound, and *motion*s are all *energy*.

EALR 4: **Earth and Space Science**

Big Idea: **Earth in Space (ES1)**

Core Content: ***The Sun's Daily Motion***

In prior grades students learned that some of the objects they see in the sky change from minute to minute, while other things can be seen to follow patterns of movement if observed carefully over time. In grades 2-3 students learn that carefully observing and recording shadows provides an excellent way to trace the daily apparent movement of the Sun through the sky, which extends their observational skills. In later years, students will use this knowledge to realize that the Sun's apparent movement reflects Earth's daily spin on its axis.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
2-3 ES1A	Outdoor shadows are longest during the morning and evening and shortest during the middle of the day. These changes in the length and direction of an object's shadow indicate the changing position of the Sun during the day.	• Mark the position of shadows cast by a stick over the course of a few hours, and *infer* how the Sun has appeared to move during that time.*a • Observe that the length of shadows is shortest at about noon, and *infer* that this is because the Sun is highest in the sky (but not directly overhead) at about that time. *a • *Explain how* shadows could be used to tell the time of day.*b

Mathematics Connections

*a 2.4.A Solve problems involving properties of two- and three-dimensional figures.

*b 2.3.E Use both analog and digital clocks to tell time to the minute.

EALR 4: **Earth and Space Science**

Big Idea: **Earth Systems, Structures, and Processes *(ES2)***

Core Content: ***Water and Weather***

In prior years, students learned about Earth materials through their own observations. In grades 2-3 students learn that water exists in various locations and plays an essential role in Earth systems, including shaping land forms and weather. Weather changes from day to day, and weather conditions can be described by measurable quantities, such as temperature and rainfall. Environments can be affected by natural causes. Some of these changes are gradual and some are rapid. Water is essential for life, but it can also be destructive when too much is deposited too rapidly.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 ES2A	Water plays an essential role in Earth *systems*, including shaping landforms.	• Identify where natural water bodies occur in the students' local *environment*. Show how water has shaped a local landform (e.g., river valley, canyon, Puget Sound).
2-3 ES2B	Water can be a *liquid* or *solid* and can go back and forth from one *form* to another. If water is turned into ice and then the ice is allowed to melt, the amount of water will be the same as it was before freezing. Water occurs in the *air* as rain, snow, hail, fog, and clouds.	• *Describe* the various forms and places that water can be found on Earth as *liquids* and *solids* (e.g., as *liquid* in morning dew; in lakes, streams, and oceans; as *solid* ice at the North and South Poles, and on the tops of mountains; and in the *air* as clouds, fog, rain, hail, and snow). • *Predict* that the *weight* of a sample of water will be nearly the same before and after it is frozen or melted. *Explain* why the *weight* will be almost the same.*a
2-3 ES2C	Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as *temperature* and *precipitation*.	• Measure and record changes in weather (e.g., inches of rain using a *rain gauge*, depth of snow using a ruler, and *temperature* using a *thermometer*).*a • *Interpret* graphs of weather conditions to *describe* with measurements how weather changes from season to season.*b

Mathematics Connections

*a	2.3.C	Measure length to the nearest whole unit in both metric and U.S. customary units.
	3.5.B	Measure temperature in degrees Fahrenheit and degrees Celsius, using a thermometer.
*b	2.4.B	Collect, organize, represent, and interpret data in bar graphs and picture graphs.
	3.5.E	Construct and analyze pictographs, frequency tables, line plots, and bar graphs.

Note: Students are not expected to convert between English and metric units at this grade level.

EALR 4: **Earth and Space Science**

Big Idea: **Earth History *(ES3)***

Core Content: ***None***

No standards for 2-3 Earth History because content on fossils would duplicate content in 2-3 LS3 Biological Evolution.

EALR 4: **Life Science**

Big Idea: **Structures and Functions of Living Organisms (LS1)**

Core Content: ***Life Cycles***

In prior grades students learned that living things have basic needs and they meet those needs in various ways. In grades 2-3 students learn that all plants and animals have life cycles. They also compare the life cycles of a few common animals to see how they are similar and how they are different, and learn about the life cycles of plants. Focus should be on observable characteristics of how plants and animals change over time. An important aspect of life cycles is that plants and animals resemble their parents. This is a first step in understanding how the structures of plants and animals develop and function.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 LS1A	Plants have *life cycles* that include sprouting, growing to full size, forming fruits and flowers, shedding seeds (which begins a new cycle), and eventually dying. The details of the *life cycle* are different for different plants.	• *Describe* the *life cycle* of a *common* type of plant (e.g., the growth of a fast-growing plant from seed to sprout, to adult, to fruits, flowers, and seeds).
2-3 LS1B	Animals have *life cycles* that include being born; developing into juveniles, adolescents, then adults; reproducing (which begins a new cycle); and eventually dying. The details of the *life cycle* are different for different animals.	• *Describe* the *life cycle* of a *common* type of animal (e.g., the development of a butterfly or moth from egg to larva to pupa to adult, or the development of a frog from egg to tadpole to adult frog).

EALR 4: **Life Science**

Big Idea: **Ecosystems (LS2)**

Core Content: ***Changes in Ecosystems***

In prior grades students learned that all plants and animals live in and depend on habitats. In grades 2-3 students learn that ecosystems include plant and animal populations as well as nonliving resources. Plants and animals depend both on each other and on the nonliving resources in their ecosystem to survive. Ecosystems can change through both natural causes and human activities. These changes might be good or bad for the plants and animals that live in the ecosystem, or have no effect. Humans can protect the health of ecosystems in a number of ways.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 LS2A	*Ecosystems* support all life on the planet, including human life, by providing food, fresh water, and breathable *air*.	• Identify at least four ways that *ecosystems* support life (e.g., by providing fresh water, generating oxygen, removing toxic pollutants, and providing sources of useful materials).
2-3 LS2B	All *ecosystems* change over time as a result of natural causes (e.g., storms, floods, volcanic eruptions, fire). Some of these changes are beneficial for the plants and animals, some are harmful, and some have no *effect*.	• *Describe* three or more of the changes that occur in an *ecosystem* or a *model* of a natural *ecosystem* (e.g., aquarium, terrarium) over time, as well as how these changes may affect the plants and animals living there.*a
2-3 LS2C	Some changes in *ecosystems* occur slowly and others occur rapidly. Changes can affect life forms, including humans.	• *Explain* the consequences of rapid *ecosystem* change (e.g., flooding, *wind* storms, snowfall, and volcanic eruptions). • *Explain* the consequences of gradual *ecosystem* change (e.g., gradual increase or decrease in daily *temperatures*, reduction or increase in yearly rainfall).
2-3 LS2D	Humans impact *ecosystems* in both positive and negative ways. Humans can help improve the health of *ecosystems* so that they provide *habitats* for plants and animals and resources for humans over the long term. For example, if people use fewer resources and recycle waste, there will be fewer negative impacts on natural *systems*.	• *Describe* a change that humans are making in a particular *ecosystem* and *predict* how that change could harm or improve conditions for a given type of plant or animal.*b • Propose a plan to protect or improve an *ecosystem*.

Mathematics Connections

*a	2.4.B	Collect, organize, represent, and interpret data in bar graphs and picture graphs.
	3.5.E	Construct and analyze pictographs.
*b	3.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 4: **Life Science**

Big Idea: **Biological Evolution (LS3)**

Core Content: ***Variation of Inherited Characteristics***

In prior grades students learned that some objects are alive and others are not, and that many living things can be classified as either plants or animals. In grades 2-3 students learn about variations in inherited characteristics. That is, when plants and animals reproduce, the offspring closely resemble their parents. But the offspring are not exactly the same as their parents. Variations among animals and plants can help them survive changing conditions. Those plants and animals unable to survive and reproduce become extinct. Fossils represent the remains of plants and animals, including some that are extinct. Many extinct plants and animals looked something like plants and animals that are alive today, while others were very different from anything alive today. This topic engages students in looking closely at plants and animals and noticing similarities and subtle differences. It also lays the foundation for later study of Evolution and of Earth History.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
2-3 LS3A	There are *variations* among the same kinds of plants and animals.	• Give examples of *variations* among individuals of the same kinds of plants and animals within a *population* (e.g., tall and short pine trees, black cats and white cats, people with blue eyes or brown eyes, with freckles or without).
2-3 LS3B	The offspring of a plant or animal closely resembles its parents, but close inspection reveals differences.	• *Compare* the offspring of a plant or animal with its parents, listing features that are similar and that are different.
2-3 LS3C	Sometimes differences in *characteristics* give individual plants or animals an advantage in surviving and reproducing.	• *Predict* how differences in *characteristics* might help one individual survive better than another (e.g., animals that are stronger or faster, plants or animals that blend into the background, plants that grow taller or that need less water to survive).
2-3 LS3D	*Fossils* are often similar to parts of plants or animals that live today.	• Observe *fossils* and *compare* them to similar plants or animals that live today (e.g., *compare* a *fossil* fern with a similar fern that grows today, a dinosaur leg bone with the leg bone of a reptile that lives today, a mastodon and an elephant).
2-3 LS3E	Some *fossils* are very different from plants and animals that live today.	• Conclude from *fossil evidence* that once there were *species* on Earth that are no longer alive (e.g., T-Rex, trilobites). • Given pictures of animals that are *extinct* (e.g., dinosaurs, mammoths), *describe* how these animals are different from animals that live today.

Science Standards
Grade 4-5

The science standards for grades 4-5 consist of nine Core Content Standards within the science domains. These standards should be learned during the two-year grade span, so that only four or five of them need to be learned ***in depth*** each year. Local school district curriculum teams will decide which of the areas will be learned at which grade level, depending on students' needs and interests.

As illustrated by the grid below, the three crosscutting EALRs of Systems, Inquiry, and Application are not to be learned in isolation, but rather in conjunction with content in the science domains. Not every topic needs to address all three crosscutting EALRs. But in any given year, content in Systems, Inquiry, and Application should be experienced in the context of several science lessons, so that students can see the commonalities among the fields of science.

Grades 4-5 **EALR 4 Domains of Science**	**EALR 1** **Systems** **SYS**	**EALR 2** **Inquiry** **INQ**	**EALR 3** **Application** **APP**
Physical Science PS1 Measurement of Force and Motion PS2 States of Matter PS3 Heat, Light, Sound, and Electricity **Earth and Space Science** ES1 Earth in Space ES2 Formation of Earth Materials ES3 Focus on Fossils **Life Science** LS1 Structures and Behaviors LS2 Food Webs LS3 Heredity and Adaptation	Complex Systems	Planning Investigations	Different Technologies

EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Complex Systems***

In prior grades students learned to think systematically about how the parts of objects, plants, and animals are connected and work together. In grades 4-5 students learn that systems contain smaller (sub-) systems, and that systems are also parts of larger systems. The same ideas about systems and their parts learned in earlier grades apply to systems and subsystems. In addition, students learn about inputs and outputs and how to predict what may happen to a system if the system's inputs are changed. The concept of a hierarchy of systems provides a conceptual bridge for students to see the connections between mechanical systems (e.g., cities) and natural systems (e.g., ecosystems).

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 SYSA	*Systems* contain *subsystems*.	• Identify at least one of the *subsystems* of an object, plant, or animal (e.g., an airplane contains *subsystems* for propulsion, landing, and *control*).
4-5 SYSB	A *system* can do things that none of its *subsystems* can do by themselves.	• Specify how a *system* can do things that none of its *subsystems* can do by themselves (e.g., a forest *ecosystem* can sustain itself, while the trees, soil, plant, and animal *population*s cannot).
4-5 SYSC	Systems have *inputs* and *outputs*. Changes in *inputs* may change the *outputs* of a *system*.	• *Describe* what goes into a *system* (*input*) and what comes out of a *system* (*output*) (e.g., when making cookies, *inputs* include sugar, flour, and chocolate chips; *outputs* are finished cookies). • *Describe* the *effect* on a *system* if its *input* is changed (e.g., if sugar is left out, the cookies will not taste very good).
4-5 SYSD	One defective part can cause a *subsystem* to malfunction, which in turn will affect the *system* as a whole.	• *Predict* what might happen to a *system* if a part in one or more of its *subsystems* is missing, broken, worn out, mismatched, or misconnected (e.g., a broken toe will affect the skeletal *system*, which can greatly reduce a person's ability to walk).*a

Mathematics Connections

*a 4.5.J, 5.6.J Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Planning Investigations***

In prior grades students learned to conduct different kinds of investigations. In grades 4-5 students learn to plan an investigation, which involves first selecting the appropriate kind of investigation to match the question being asked. One type of investigation is a controlled experiment (a "fair test"). Others include systematic observation, field studies, and models and simulations. Students can also collect, display, and interpret data; summarize results; draw conclusions from evidence; and communicate their findings. Students are aware that scientific explanations emphasize evidence, involve logical arguments, and are consistent with scientific principles and theories. Students are also expected to communicate their findings and to critique the investigations of others with respect and intellectual honesty. These capabilities are essential in preparing students for the more extensive and rigorous investigations that they will be planning and conducting in middle school.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 INQA Question	Scientific *investigation*s involve asking and answering *questions* and comparing the answers with *evidence* from the real world.	• Identify the *questions* being asked in an *investigation*. Gather scientific *evidence* that helps to answer a *question*. *a
4-5 INQB Investigate	Scientists plan and conduct different kinds of *investigation*s, depending on the *questions* they are trying to answer. Types of *investigation*s include systematic *observations* and descriptions, *field studies*, *models*, and *open-ended explorations* as well as *controlled experiments*.	• Given a research *question*, plan an appropriate *investigation*, which may include systematic *observations*, *field studies*, *models*, *open-ended explorations*, or *controlled experiment*s. • Work collaboratively with other students to carry out a *controlled experiment*, selecting appropriate *tools* and demonstrating safe and careful use of equipment.
4-5 INQC Investigate	An *experiment* involves a *comparison*. For an *experiment* to be valid and fair, all of the things that can possibly change the outcome of the *experiment* should be kept the same, if possible.	• Conduct or *critique* an *experiment*, noting when the *experiment* might not be fair because things that might change the outcome are not kept the same.
4-5 INQD Investigate	*Investigation*s involve systematic collection and recording of relevant *observations* and data.	• Gather, record, and organize data using appropriate units, tables, graphs, or maps.
4-5 INQE Investigate	Repeated *trials* are necessary for *reliability*.	• *Explain that* additional *trials* are needed to ensure that the results are repeatable.
4-5 INQF Models	A scientific *model* is a simplified representation of an object, event, *system*, or process created to understand some aspect of the *natural world*. When learning from a *model*, it is important to realize that the *model* is not exactly the same as the thing being modeled.	• Create a simple *model* to represent an event, *system*, or process. • Use the *model* to learn something about the event, *system*, or process. • *Explain how* the *model* is similar to and different from the thing being modeled.
4-5 INQG Explain	Scientific explanations emphasize *evidence*, have logically consistent arguments, and use known scientific *principles*, *model*s, and *theories*.	• *Generate* a *conclusion* from a scientific *investigation* and show how the *conclusion* is supported by *evidence* and other scientific *principles*.*c

Standards for Grades 4-5

	Content Standards	Performance Expectations
4-5 INQH Communicate	Scientists *communicate* the results of their *investigations* verbally and in writing. They review and ask *questions* about the results of other scientists' work.	• Display the findings of an *investigation* using tables, graphs, or other visual means to represent the data accurately and meaningfully.*b • *Communicate* to peers the purpose, procedure, results, and *conclusion*s of an *investigation*. • Respond non-defensively to comments and *questions* about their *investigation*. • Discuss differences in findings and *conclusion*s reported by other students.
4-5 INQI Intellectual Honesty	Scientists report the results of their *investigations* honestly, even when those results show their predictions were wrong or when they cannot *explain* the results.	• *Explain* why records of *observations* must never be changed, even when the *observations* do not match expectations.

Mathematics Connections

*a	4.5.A, 5.6.A	Determine the question(s) to be answered, given a problem situation.
*b	5.5.C	Construct and interpret line graphs.
*c	4.5.J, 5.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.
	5.5.B	Determine and interpret the mean of a small data set of whole numbers.

Note: This standard is closely aligned to Core Processes 4.5 and 5.6.

EALR 3: Application

Big Idea: Application (APP)

Core Content: *Different Technologies*

In earlier grades, students learned to design a solution to a simple problem, using an elementary version of the technological design process. In grades 4-5 students learn to distinguish between science and technology and to work individually and collaboratively to produce a product of their own design. They learn that people in different cultures use different materials and technologies to meet their same daily needs and increase their understanding of tools and materials. Students also develop their abilities to define problems that can be solved by modifying or inventing technologies, to create and test their designs, and to communicate what they learned. These capabilities help students understand the value of science and technology to meet human needs and provide them with valuable skills for everyday life.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 APPA	*Technology* involves changing the *natural world* to meet human needs or wants.	• *Describe* ways that people use *technology* to meet their needs and wants (e.g., text messages to *communicate* with friends, use bicycles or cars for transportation).
4-5 APPB	People in different *cultures* all around the world use different materials or technologies to solve the same problems.	• Give examples of how people around the world use different materials or technologies to solve the same problem (e.g., people in different countries use different materials to build their houses).
4-5 APPC	Problems of moderate complexity can be solved using the *technological design process.* This process begins by defining and researching the problem to be solved.	• Define a problem and list several *criteria* for a successful *solution.* • Research the problem to better understand the need and to see how others have solved similar problems.
4-5 APPD	Scientists and engineers often work in teams with other individuals to *generate* different *ideas* for solving a problem.	• Work with other students to *generate* possible *solutions* to a problem and agree on the most promising *solution* based on how well each different *idea* meets the *criteria* for a successful *solution*.*a
4-5 APPE	Possible *solutions* should be tested to see if they solve the problem. Building a *model* or prototype is one way to test a possible *solution*.	• Use suitable *tools*, techniques, and materials to make a drawing or build a *model* or prototype of the proposed *design*. • Test the *solution* to see how well that *solution* solves the problem. Modify the *design*, if necessary.*a
4-5 APPF	*Solutions* to problems must be communicated, if the problem is to be solved.	• *Communicate* the *solution*, results of any tests, and modifications persuasively, using oral, written, and/or pictorial representations of the process and product.
4-5 APPG	Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication.	• *Describe* specific ways that science and technology have improved the quality of the students' lives.

	Content Standards	Performance Expectations
4-5 APPH	People of all ages, interests, and abilities engage in a variety of scientific and technological work.	• *Describe* several activities or careers that require people to *apply* their knowledge and abilities in *science*, *technology*, engineering, and mathematics.

Mathematics Connections

*a	4.5.H, 5.6.H	Analyze and evaluate whether a solution is reasonable and mathematically correct, and answers the question.

EALR 4: **Physical Science**

Big Idea: **Force and Motion (PS1)**

Core Content: ***Measurement of Force and Motion***

In prior grades students learned that forces work not only to push and pull objects, but also to affect objects when they are dropped or thrown. In grades 4-5 students learn how to use basic tools to measure the fundamental quantities of force, time, and distance. Force can be measured with a spring scale. Distance and time can be measured by a variety of methods, and the results can be used to compare the motion of two objects. Focusing on accuracy of measurement, recording of data and logical conclusions from the data provide the foundation for future years when students will undertake more complex investigations.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
4-5 PS1A	The *weight* of an object is a measure of how strongly it is pulled down toward the ground by *gravity*. A spring scale can measure the pulling *force*.	• Use a spring scale to measure the *weights* of several objects accurately. *Explain that* the *weight* of an object is a measure of the *force* of *gravity* on the object. Record the measurements in a table.*a
4-5 PS1B	The relative *speed* of two objects can be determined in two ways: (1) If two objects travel for the same amount of time, the object that has traveled the greatest distance is the fastest. (2) If two objects travel the same distance, the object that takes the least time to travel the distance is the fastest.	• Measure the distance that an object travels in a given interval of time and *compare* it with the distance that another object moved in the same interval of time to determine which is fastest.*b • Measure the time it takes two objects to travel the same distance and determine which is fastest.*c

Mathematics Connections

*a	3.5.C	Estimate, measure, and *compare* weight and mass, using appropriate-size U.S. customary and metric units.
*b	2.3.C	Measure length to the nearest whole unit in both metric and U.S. customary units.
*c	4.4.C	Estimate and determine elapsed time, using a calendar, a digital clock, and an analog clock.

EALR 4: **Physical Science**

Big Idea: **Matter: Properties and Change (PS2)**

Core Content: ***States of Matter***

In prior grades students learned to identify different physical properties of matter and to realize that an object may be made from several different types of materials. In grades 4-5 students learn that a given substance may exist in different states—solid, liquid, and gas—and that many substances can be changed from one state to another. This understanding of matter lays the foundation for later explanations of matter in terms of atomic theory.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 PS2A	Substances can exist in different physical states—*solid, liquid,* and *gas.* Many substances can be changed from one state to another by heating or cooling.	• *Explain that* water is still the same substance when it is frozen as ice or *evaporated* and becomes a *gas.*[1]
4-5 PS2B	*Air* is a *gas*. *Air* fills a closed container completely. *Wind* is moving *air.*	• *Explain that* a balloon expands when you blow *air* into it because blowing *air* into the balloon creates greater *air* pressure inside the balloon than outside the balloon. • *Describe* how the *wind* can move things (e.g., *wind* can move the branches of trees when it blows and moves sailboats through the water).
4-5 PS2C	The total amount of *matter* is *conserved* (stays the same) when it undergoes a *physical change* such as when an object is broken into tiny pieces, when a *solid* is dissolved in a *liquid,* or when *matter* changes state (*solid, liquid, gas*).	• *Explain that* dissolved substances have not disappeared, and cite *evidence* to determine that the substance is still there (e.g., sprinkle sugar on cereal, add milk, and you can taste it even though you can no longer see the sugar). • *Predict* that the *weight*[2] of a sample of water will be nearly the same before and after it is frozen or melted. *Explain* why the *weight* will be almost the same.*a • If an object is weighed, then broken into small pieces, *predict* that the small pieces will weigh the same as the large piece. *Explain* why the *weight* will be the same.*a

Mathematics Connections

*a	4.5.J, 5.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.

[1]**Note:** At this age and grade level, the term "steam" is acceptable as a replacement for "water vapor."

[2]**Note:** Although the correct term is "*mass*," elementary school students are not expected to distinguish between the terms "mass" and "*weight*."

EALR 4: **Physical Science**

Big Idea: **Energy: Transfer, Transformation and Conservation (PS3)**

Core Content: ***Heat, Light, Sound, and Electricity***

In prior grades students learned to identify several different forms of energy. In grades 4-5 students build on their intuitive understanding of energy and learn how heat, light, sound, and electrical energy are generated and can be transferred from place to place. For example, they can observe that energy of motion can be transferred from one object to another. They can observe how heat energy is generated and moves from a warmer to a cooler place, and how sound can be produced by vibrations in the throat or guitar strings or other forms of vibration. They can also see that electrical energy can do many things, including producing light, heat, and sound, and can make things move. This introduction to the many forms of energy helps to prepare students for later studies of energy transformation and conservation.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 PS3A	*Energy* has many forms, such as *heat*, light, sound, *motion*, and electricity.	• Identify different forms of *energy* (e.g., *heat*, light, sound, *motion*, electricity) in a *system*.
4-5 PS3B	*Energy* can be *transferred* from one place to another.	• Draw and label diagrams showing several ways that *energy* can be *transferred* from one place to another (e.g., sound *energy* passing through *air*, electrical *energy* through a wire, *heat energy* conducted through a frying pan, light *energy* through space).
4-5 PS3C	*Heat energy* can be *generated* a number of ways and can move (*transfer*) from one place to another. *Heat energy* is *transferred* from warmer things to colder things.	• Identify several ways to *generate heat energy* (e.g., lighting a match, rubbing hands together, or mixing different kinds of chemicals together). • Give examples of two different ways that *heat energy* can move from one place to another, and *explain* which direction the *heat* moves (e.g., when placing a pot on the stove, *heat* moves from the hot burner to the cooler pot).
4-5 PS3D	Sound *energy* can be *generated* by making things vibrate.	• Demonstrate how sound can be *generated* by vibrations, and *explain how* sound *energy* is *transferred* through the *air* from a source to an observer.
4-5 PS3E	Electrical *energy* in circuits can be changed to other forms of *energy*, including light, *heat*, sound, and *motion*. *Electric circuits* require a complete loop through conducting materials in which an electric current can pass.	• Connect wires to produce a complete circuit involving a battery and at least one other electrical component to produce observable change (e.g., light a bulb, sound a buzzer, and make a bell ring). • Repair an *electric circuit* by completing a closed loop. • *Describe* how electrical *energy* is *transferred* from one place to another, and how it is *transformed* from electrical *energy* to different kinds of *energy* in the circuit above.

EALR 4: **Earth and Space Science**

Big Idea: **Earth in Space (ES1)**

Core Content: ***Earth in Space***

In prior grades students learned that observing and recording the position and appearance of objects in the sky make it possible to discover patterns of motion. In grades 4-5 students learn the full implications of the spherical-Earth concept and Earth's place in the Solar System. The upper elementary years are an excellent time for study of the Earth in space because students have the intellectual capacity to grasp the spherical-Earth concept and the relationship between the Earth and Sun. This major set of concepts is a stepping-stone to a later understanding of all concepts in astronomy and space science and an essential element to further understanding of how the Earth and other planets formed.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 ES1A	Earth is approximately *spherical* in shape. Things on or near the Earth are pulled toward Earth's center by the *force* of *gravity*.	• Give *evidence* to support the *idea* that Earth is *spherical* in shape (e.g., research Earth images from space, shape of Earth's shadow on the *Moon* during an *eclipse* of the *Moon*). • Draw how objects would fall when dropped from various places around Earth, demonstrating that all things fall "down" toward Earth's center.
4-5 ES1B	Earth's daily spin relative to the Sun causes night and day.	• Use a physical *model* or diagram to show that Earth's spin causes night and day.
4-5 ES1C	Earth's nearly circular yearly *orbit* around the Sun causes us to see different *constellations* at different times of year.	• Use a physical *model* or diagram to show how the different *constellations* are visible in different seasons, as a consequence of Earth *orbiting* the sun.
4-5 ES1D	The Sun is a star. It is the central and largest body in our *Solar System.* The Sun appears much brighter and larger in the sky than other stars because it is many thousands of times closer to Earth.	• Identify that our *Solar System* contains only one star, the Sun. • *Explain that* the Sun appears brighter and larger than any other star because it is very close to us.

EALR 4: **Earth and Space Science**

Big Idea: **Earth Systems, Structures, and Processes (ES2)**

Core Content: ***Formation of Earth Materials***

In prior years, students learned that water plays an essential role in Earth systems, including shaping landforms and weather. In grades 4-5 students learn how Earth materials change and how they can be used for various purposes. They learn that Earth materials include solid rocks and soil, water, and gases of the atmosphere. People use many of these materials as resources to meet their needs. One of the most important Earth resources is soil, since people depend on fertile soil to grow food. The processes that produce soils offer an excellent opportunity for students to understand how Earth materials change gradually over time, and provide a solid grounding for later study of landforms and large-scale changes of Earth's surface that students will learn in middle school.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 ES2A	Earth materials include *solid* rocks and soil, water, and *gases* of the *atmosphere*. Materials have different physical and *chemical properties* which make them useful in different ways. Earth materials provide many of the resources that humans use.	• *Describe* Earth materials and list their physical and *chemical properties*. • *Explain how* the *properties* of an Earth material make it useful for certain purposes, but not useful for other purposes (e.g., rocks are heavy and strong so they are good for building walls, but they are not as useful as lighter materials for roofs). • Give examples of *human-made* materials, including those that are changed only a little (e.g., wood and stones used for building) and those that look very different from the raw materials (e.g., metal, ceramics, and plastics).
4-5 ES2B	*Weathering* is the breaking down of rock into pebbles and sand caused by physical processes such as heating, cooling, and pressure, and chemical processes such as acid rain.	• *Describe* and give examples of the physical and chemical processes of *weathering* of rock.
4-5 ES2C	*Erosion* is the movement of Earth materials by forces such as *wind*, moving water, ice forming, and *gravity*.	• *Describe* how water and *wind* cause *erosion*. • Identify local examples where *erosion* has occurred and *describe* the most likely cause of the *erosion*.
4-5 ES2D	Soils are formed by *weathering* and *erosion*, decay of plant *matter*, transport by rain through streams and rivers, and *deposition* of *sediments* in valleys, riverbeds, and lakes.	• *Explain how* the formation of soils is related to the following processes: *weathering* of rock; decay of plant *matter*; transport by rain, streams, and rivers; *deposition of sediments* in rivers and lakes.
4-5 ES2E	Soils are often found in layers, with each layer having a different chemical composition and different physical *properties*.	• *Compare* different layers in soil with respect to physical *properties* (e.g., color, texture, particle size, amount of dead plant and animal material, capacity for holding water).
4-5 ES2F	*Erosion* plays an important role in the formation of soil, but too much *erosion* can wash away fertile soil from *ecosystems* and farms.	• *Explain* the role that *erosion* plays in forming soils and how *erosion* can also deplete soils. • *Describe* methods people use to reduce soil *erosion*.

EALR 4: **Earth and Space Science**

Big Idea: **Earth History (ES3)**

Core Content: ***Focus on Fossils***

In prior years, students learned that fossils represent the remains of plants and animals that lived long ago. In grades 4-5 students learn that fossils also provide evidence of environmental conditions that existed when the fossils formed. Most fossils are imprints formed when plants or animals died in a watery environment and were covered with mud that eventually hardened into rock. Fossils can also form in other ways, as when dissolved minerals seep into a piece of wood and harden into rock, or an animal is frozen in ice that never thaws. Fossils provide evidence of the kinds of plants and animals that lived on Earth in the past, as well as environmental conditions that prevailed at the time the fossils formed.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 ES3A	Different kinds of events caused the formation of different kinds of *fossils*.	• *Describe* an event that could cause the formation of a given *fossil* (e.g., the plant or animal may have been buried in *sediment* that hardened into rock and left an imprint, or dissolved minerals may have seeped into a piece of wood and hardened into rock).*a
4-5 ES3B	By studying the kinds of plant and animal *fossils* in a layer of rock, it is possible to *infer* what the *environment* was like at the time and where the layer formed.	• *Infer* from a picture of several *fossils* in a layer of rock the *environmental* conditions that existed when the *fossils* were formed (e.g., fish *fossils* would indicate that a body of water existed at the time the *fossils* formed).*a

Mathematics Connections

*a	4.5.J, 5.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.

Note: This standard overlaps very closely with Life Science: Biological Evolution at the 4th-5th grade level.

EALR 4: **Life Science**

Big Idea: **Structures and Functions of Living Organisms (LS1)**

Core Content: ***Structures and Behaviors***

In prior years, students learned that all plants and animals have life cycles. In grades 4-5 students learn that plants and animals have different structures that work together to respond to various internal and external needs. Students compare various human and animal structures and reflect on how the different structures enable the organism to respond to external and internal needs. Students also learn that healthy body structures depend on good nutrition. These concepts are stepping-stones to later understanding of how structures are built up from cells.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 LS1A	Plants and animals can be sorted according to their structures and behaviors.	• Sort plants and animals according to their structures (e.g., presence of hair, feathers, or scales on their skin) and behaviors (e.g., grazing, hunting, or diving for food).
4-5 LS1B	Plants and animals have different structures and behaviors that serve different *functions*.	• List parts of an animal's body and *describe* how it helps the animal meet its basic needs (e.g., the bones support the body so it can move; the blood carries food and oxygen throughout the body). • *Describe* the *function* of a given animal behavior (e.g., salmon swim upstream to spawn, owls hunt at night when prey are vulnerable).*a
4-5 LS1C	Certain structures and behaviors enable plants and animals to respond to changes in their *environment*.	• Give examples of how plants and animals respond to their *environment* (e.g., many plants grow toward the light, animals hide when they see a predator).
4-5 LS1D	Plants and animals have structures and behaviors that respond to internal needs.	• Give examples of how plants and animals respond to internal needs (e.g., plants wilt when they don't have water; animals seek food when they are hungry).
4-5 LS1E	Nutrition is essential to health. Various kinds of foods are necessary to build and maintain body structures. Individuals have responsibility for their own health and food choices.	• *Describe* how various types of foods contribute to the maintenance of healthy body structures. • Develop a balanced plan for eating that will allow you to build and maintain your body.

Mathematics Connections

*a 4.5.J, 5.6.J Make and test conjectures based on data (or information) collected from explorations and experiments.

Standards for Grades 4-5

EALR 4: **Life Science**
Big Idea: **Ecosystems (LS2)**
Core Content: ***Food Webs***

In prior grades students learned that ecosystems include both plant and animal populations as well as nonliving resources, and that plants and animals depend on one another and on the nonliving resources in their ecosystem to survive. In grades 4-5 students learn how ecosystems change and how these changes affect the capacity of an ecosystem to support populations. Some changes in ecosystems are caused by the organisms themselves. The ability of any organism to survive will depend on its characteristics and behaviors. Humans also play an important role in many ecosystems and may reduce negative impacts through thoughtful use of natural resources. Concepts related to ecosystems, including food webs, make it possible for students to understand the interrelationships among various forms of life and between living things and their environment.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 LS2A	An *ecosystem* includes all of the *populations* of living *organisms* and nonliving physical factors in a given area. Living *organisms* depend on one another and the nonliving physical factors in their *ecosystem* to help them survive.	• Identify the living and nonliving parts of an ecosystem. • Give examples to show how the plants and animals depend on one another for survival (e.g., worms *decompose* waste and return *nutrients* to the soil, which helps plants grow). • *Describe* how the plants and animals in an *ecosystem* depend on nonliving resources.
4-5 LS2B	Plants make their own food using *energy* from the sun. Animals get food *energy* by eating plants and/or other animals that eat plants. Plants make it possible for animals to use the *energy* of sunlight.	• *Explain that* plants make their own food, and animals, including humans, get food by eating plants and/or eating other animals.
4-5 LS2C	Plants and animals are related in *food webs* with *producers* (plants that make their own food), *consumers* (animals that eat *producers* and/or other animals), and *decomposers* (primarily bacteria and fungi) that break down wastes and dead *organisms*, and return *nutrients* to the soil.	• Draw a simple *food web* given a list of three *common organisms*. Draw arrows properly and identify the *producers* and *consumers*. • *Compare* the roles of *producers*, *consumers*, and *decomposers* in an *ecosystem.*
4-5 LS2D	*Ecosystems* can change slowly or rapidly. Big changes over a short period of time can have a major impact on the *ecosystem* and the *populations* of plants and animals living there.	• *Apply* knowledge of a plant or animal's *relationship* to its *ecosystem* and to other plants and animals to *predict* whether and how a slow or rapid change in the *ecosystem* might affect the *population* of that plant or animal.*a
4-5 LS2E	All plants and animals change the *ecosystem* where they live. If this change reduces another organism's access to resources, that *organism* may move to another location or die.	• *Describe* how one *population* may affect other plants and/or animals in the *ecosystem* (e.g., increase in Scotch Broom replaces native plants normally eaten by butterfly caterpillars, reducing the butterfly *population*).

	Content Standards	Performance Expectations
4-5 LS2F	People affect *ecosystems* both positively and negatively.	• *Describe* ways that humans can improve the health of *ecosystems* (e.g., recycling wastes, establishing rain gardens, planting native *species* to prevent flooding and *erosion*). • *Describe* ways that humans can harm the health of *ecosystems* (e.g., overuse of fertilizers, littering, not recycling)

Mathematics Connections

*a	4.5.J, 5.6.J	Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 4: **Life Science**

Big Idea: **Biological Evolution (LS3)**

Core Content: ***Heredity and Adaptation***

In prior grades students learned about variations in inherited characteristics. In grades 4-5 students learn that some differences in inherited characteristics may help plants and animals survive and reproduce. Sexual reproduction results in offspring that are never identical to either of their parents and therefore contributes to a species' ability to adapt to changing conditions. Heredity is a key feature of living plants and animals that enables changes in characteristics to be passed on and for species to change over time. Fossils provide evidence of what ancient extinct plants and animals looked like.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
4-5 LS3A	In any *ecosystem*, some *populations* of *organisms* thrive and grow, some decline, and others do not survive at all.	• List some reasons why some *populations* may not survive as well as others.*a • *Evaluate* similar *populations* in an *ecosystem* with regard to their ability to thrive and grow (e.g., bird *populations* with differently colored feathers). *a
4-5 LS3B	Plants and animals inherit many *characteristics* from their parents. Some inherited *characteristics* allow *organisms* to better survive and reproduce in a given *ecosystem*.	• *Communicate* that plants and animals inherit many *characteristics* (e.g., color of a flower or number of limbs at birth) from the parents of the plant or animal. • Give examples to illustrate an inherited *characteristic* that would enable an *organism* to better survive and reproduce in a given *ecosystem*.
4-5 LS3C	Some *characteristics* and behaviors result from an individual plant's or animal's *interactions* with the *environment* and are not passed from one *generation* to the next by *heredity*.	• Use an example to *explain that* some *characteristics* or behaviors result from an individual plant's or animal's *interactions* with the *environment* and are not passed from one *generation* to the next by *heredity* (e.g., trees can lose a limb, animals can have accidents that cause scars, people can exercise and build muscles).
4-5 LS3D	*Fossils* provide *evidence* that many plant and animal *species* are extinct and that *species* have changed over time.	• *Compare* and *contrast fossils* with one another and with living plants and animals to illustrate that *fossils* provide *evidence* that plant and animal *species* have changed over time.

Mathematics Connections

*a 4.4.F Describe and *compare* the likelihood of events.

Science Standards
Grades 6-8

The science standards for grades 6-8 consist of nine Core Content Standards within the science domains. These standards should be learned during the three-year grade span, so that only three of them need to be learned ***in depth*** each year. Local school district curriculum teams will decide which of the areas will be learned at which grade level, depending on students' needs and interests.

As illustrated by the grid below, the three crosscutting EALRs of Systems, Inquiry, and Application are not to be learned in isolation, but rather in conjunction with content in the science domains. Not every topic needs to address all three crosscutting EALRs. But in any given year, content in Systems, Inquiry, and Application should be experienced in the context of several science lessons so that students can see the commonalities among the fields of science.

Grades 6-8 **EALR 4 Domains of Science**	**EALR 1 Systems SYS**	**EALR 2 Inquiry INQ**	**EALR 3 Application APP**
Physical Science PS1 Balanced and Unbalanced Forces PS2 Atoms and Molecules PS3 Interactions of Energy and Matter **Earth and Space Science** ES1 The Solar System ES2 Cycles in Earth Systems ES3 Evidence of Change **Life Science** LS1 From Cells to Organisms LS2 Flow of Energy Through Ecosystems LS3 Inheritance, Variation, and Adaptation	Inputs, Outputs, Boundaries and Flows	Questioning and Investigating	Science, Technology, and Problem Solving

EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Inputs, Outputs, Boundaries, and Flows***

In prior grades students learned about the functioning of simple systems, including inputs and outputs. In grades 6-8 students learn how to use systems thinking to simplify and analyze complex situations. Systems concepts that students learn to apply at this level include choosing system boundaries, determining if a system is open or closed, measuring the flow of matter and energy through a system, and applying systems thinking to a complex societal issue that involves science and technology. These insights and abilities can help students see the connections between and among the domains of science and among science, technology, and society.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 SYSA	Any *system* may be thought of as containing *subsystems* and as being a *subsystem* of a larger *system.*	• Given a *system*, identify *subsystems* and a larger encompassing *system* (e.g., the heart is a *system* made up of tissues and cells, and is part of the larger circulatory *system*).
6-8 SYSB	The boundaries of a *system* can be drawn differently depending on the features of the *system* being *investigated*, the size of the *system*, and the purpose of the *investigation.*	• *Explain how* the boundaries of a *system* can be drawn to fit the purpose of the study (e.g., to study how insect *populations* change, a *system* might be a forest, a meadow in the forest, or a single tree).
6-8 SYSC	The *output* of one *system* can become the *input* of another *system.*	• Give an example of how *output* of *matter* or *energy* from a *system* can become *input* for another *system* (e.g., household waste goes to a landfill).*a
6-8 SYSD	In an *open system*, *matter* flows into and out of the *system*. In a *closed system*, *energy* may flow into or out of the *system*, but *matter* stays within the *system.*	• Given a description of a *system*, *analyze* and defend whether it is open or closed.
6-8 SYSE	If the *input* of *matter* or *energy* is the same as the *output*, then the amount of *matter* or *energy* in the *system* won't change; but if the *input* is more or less than the *output*, then the amount of *matter* or *energy* in the *system* will change.	• Measure the flow of *matter* into and out of an *open system* and *predict* how the *system* is likely to change (e.g., a bottle of water with a hole in the bottom, an *ecosystem*, an *electric circuit*).*b
6-8 SYSF	The *natural* and *designed world* is complex; it is too large and complicated to *investigate* and comprehend all at once. Scientists and students learn to define small portions for the convenience of *investigation*. The units of *investigation* can be referred to as "*systems*."	• Given a complex societal issue with strong *science* and *technology* components (e.g., overfishing, global warming), *describe* the issue from a *systems* point of view, highlighting how changes in one part of the *system* are likely to influence other parts of the *system.*

Mathematics Connections

*a	6.6.D	Represent a problem situation, describe the process used to solve the problem, and verify the reasonableness of the solution.
	6.6.E	Communicate the answer(s) to the question(s) in a problem, using appropriate representations, including symbols and informal and formal mathematical language.
*b	6.6.H	Make and test conjectures based on data (or information) collected from explorations and experiments.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Questioning and Investigating***

In prior grades students learned to plan investigations to match a given research question. In grades 6-8 students learn to revise questions so they can be answered scientifically and then to design an appropriate investigation to answer the question and carry out the study. Students learn to think critically and logically to make connections between prior science knowledge and evidence produced from their investigations. Students can work well in collaborative teams and communicate the procedures and results of their investigations, and are expected to critique their own findings as well as the findings of others.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 INQA Question	Scientific *inquiry* involves asking and answering *questions* and comparing the answer with what scientists already know about the world.	• *Generate* a *question* that can be answered through scientific *investigation*. This may involve refining or refocusing a broad and ill-defined *question.*
6-8 INQB Investigate	Different kinds of *questions* suggest different kinds of scientific *investigations*.	• Plan and conduct a scientific *investigation* (e.g., *field study*, systematic *observation*, *controlled experiment*, *model*, or *simulation*) that is appropriate for the *question* being asked. • Propose a *hypothesis*, give a reason for the *hypothesis*, and *explain how* the planned *investigation* will test the *hypothesis*. • Work collaboratively with other students to carry out the *investigation*s.
6-8 INQC Investigate	Collecting, analyzing, and displaying data are essential aspects of all *investigations*.	• *Communicate* results using pictures, tables, charts, diagrams, graphic displays, and text that are clear, accurate, and informative. *a • Recognize and *interpret patterns* – as well as *variations* from previously learned or observed *patterns* – in data, diagrams, symbols, and words.*a • Use statistical procedures (e.g., median, mean, or mode) to *analyze* data and make *inferences* about *relationships*.*b
6-8 INQD Investigate	For an *experiment* to be valid, all (*controlled*) *variables* must be kept the same whenever possible, except for the *manipulated* (*independent*) *variable* being tested and the *responding (dependent) variable* being measured and recorded. If a *variable* cannot be *controlled*, it must be reported and accounted for.	• Plan and conduct a *controlled experiment* to test a *hypothesis* about a *relationship* between two *variables*. *c Determine which *variables* should be kept the same (*controlled*), which (*independent*) *variable* should be systematically *manipulated*, and which *responding (dependent) variable* is to be measured and recorded. Report any *variables* not *controlled* and *explain how* they might affect results.

	Content Standards	Performance Expectations
6-8 INQE Model	*Models* are used to represent objects, events, *systems*, and processes. *Models* can be used to test *hypotheses* and better understand *phenomena*, but they have limitations.	• Create a *model* or *simulation* to represent the behavior of objects, events, *systems*, or processes. Use the *model* to explore the *relationship* between two *variables* and point out how the *model* or *simulation* is similar to or different from the actual phenomenon.
6-8 INQF Explain	It is important to distinguish between the results of a particular *investigation* and general conclusions drawn from these results.	• *Generate* a scientific *conclusion* from an *investigation* using inferential logic, and clearly distinguish between results (e.g., *evidence*) and conclusions (e.g., explanation). • *Describe* the differences between an objective summary of the findings and an *inference* made from the findings.*c
6-8 INQG Communicate Clearly	Scientific reports should enable another investigator to repeat the study to check the results.	• Prepare a written report of an *investigation* by clearly describing the *question* being *investigated*, what was done, and an objective summary of results. The report should provide *evidence* to accept or reject the *hypothesis*, *explain* the *relationship* between two or more *variables*, and identify limitations of the *investigation*.*c
6-8 INQH Intellectual Honestly	*Science* advances through openness to new *ideas*, honesty, and legitimate *skepticism*. Asking thoughtful *questions*, querying other scientists' explanations, and evaluating one's own thinking in response to the *ideas* of others are abilities of scientific *inquiry*.	• Recognize flaws in scientific *claims*, such as uncontrolled *variables*, overgeneralizations from limited data, and experimenter bias.*c • Listen actively and respectfully to research reports by other students. Critique their presentations respectfully, using *logical argument* and *evidence*. *c • Engage in reflection and self-evaluation.
6-8 INQI *Consider* Ethics	Scientists and engineers have ethical codes governing animal *experiments*, research in natural *ecosystem*s, and studies that involve human subjects.	• Demonstrate ethical concerns and precautions in response to scenarios of scientific *investigation*s involving animal *experiments*, research in natural *ecosystems*, and studies that involve human subjects.

Mathematics Connections

*a	7.4.D	Construct and interpret histograms, stem-and-leaf plots, and circle graphs.
*b	7.4. E	Evaluate different displays of the same data for effectiveness and bias, and *explain* reasoning.
*c	7.4.C	Describe a data set, using measures of center (median, mean, and mode) and variability (maximum, minimum, and range), and evaluate the suitability and limitations of using each measurement.

Note: Mathematics process standards (6.6-8.6) overlap the science inquiry standards.

EALR 3: **Application**

Big Idea: **Application (APP)**

Core Content: ***Science, Technology, and Problem Solving***

In prior grades students learned to work individually and collaboratively to produce a product of their own design. In grades 6-8 students work with other members of a team to apply the full process of technological design, combined with relevant science concepts, to solve problems. In doing so they learn to define a problem, conduct research on how others have solved similar problems, generate possible solutions, test the design, and communicate the results. Students also investigate professions in which science and technology are required so they can learn how the abilities they are developing in school are valued in the world of work.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
6-8 APPA	People have always used *technology* to solve problems. Advances in human civilization are linked to advances in *technology*.	• *Describe* how a *technology* has changed over time in response to societal *challenges*.
6-8 APPB	Scientists and technological designers (including engineers) have different goals. Scientists answer *questions* about the *natural world*; technological designers solve problems that help people reach their goals.	• *Investigate* several professions in which an understanding of *science* and *technology* is required. *Explain* why that understanding is necessary for success in each profession.
6-8 APPC	*Science* and *technology* are interdependent. *Science* drives *technology* by demanding better instruments and suggesting *ideas* for new designs. *Technology* drives *science* by providing instruments and research methods.	• Give examples to illustrate how scientists have helped solve technological problems (e.g., how the *science* of biology has helped sustain fisheries) and how engineers have aided *science* (e.g., designing telescopes to discover distant planets).
6-8 APPD	The process of *technological design* begins by defining a problem and identifying *criteria* for a successful *solution*, followed by research to better understand the problem and brainstorming to arrive at potential *solutions*.	• Define a problem that can be solved by *technological design* and identify *criteria* for success. • Research how others solved similar problems. • Brainstorm different *solutions*.
6-8 APPE	Scientists and engineers often work together to *generate* creative *solutions* to problems and decide which ones are most promising.	• Collaborate with other students to *generate* creative *solutions* to a problem, and *apply* methods for making trade-offs to choose the best *solution*.*a
6-8 APPF	*Solutions* must be tested to determine whether or not they will solve the problem. Results are used to modify the *design*, and the best *solution* must be communicated persuasively.	• Test the best *solution* by building a *model* or other representation and using it with the intended audience. Redesign as necessary. • Present the recommended *design* using *models* or drawings and an engaging presentation.*b
6-8 APPG	The benefits of science and *technology* are not available to all the people in the world.	• *Contrast* the benefits of science and *technology* enjoyed by people in industrialized and developing nations.
6-8 APPH	People in all *cultures* have made and continue to make contributions to society through *science* and *technology*.	• *Describe* scientific or technological contributions to society by people in various *cultures*.

Mathematics Connections

*a	6.6.D	Represent a problem situation, describe the process used to solve the problem, and verify the reasonableness of the solution.
*b	6.6.E	Communicate the answer(s) to the question(s) in a problem, using appropriate representations, including symbols and informal and formal mathematical language.

Note: This standard is closely aligned to Core Processes 6.6, 7.6 and 8.5.

EALR 4: **Physical Science**

Big Idea: **Force and Motion (PS1)**

Core Content: ***Balanced and Unbalanced Forces***

In prior grades students learned to use basic tools to measure force, time, and distance. In grades 6-8 students learn to measure, record, and calculate the average speed of objects and to tabulate and graph the results. They also develop a qualitative understanding of inertia. Students learn to predict the motion of objects subject to opposing forces along the line of travel. If the forces are balanced, the object will continue moving with the same speed and direction, but if the forces are not balanced, the object's motion will change. These concepts and principles prepare students for a more formal understanding of mechanics in high school and help them make sense of the world around them.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 PS1A	*Average speed* is defined as the distance traveled in a given period of time.	• Measure the distance an object travels in a given interval of time and calculate the object's *average speed*, using $S = d/t$. (e.g., a battery-powered toy car travels 20 meters in 5 seconds, so its *average speed* is 4 meters per second).*a • Illustrate the *motion* of an object using a graph, or *infer* the *motion* of an object from a graph of the object's position vs. time or *speed* vs. time.*b
6-8 PS1B	*Friction* is a *force* that can help objects start moving, stop moving, slow down or can change the direction of the object's *motion*.	• Demonstrate and *explain* the *frictional force* acting on an object with the use of a physical *model*.
6-8 PS1C	Unbalanced *forces* will cause changes in the *speed* or direction of an object's *motion*. The *motion* of an object will stay the same when forces are balanced.	• Determine whether *forces* on an object are balanced or unbalanced and justify with observational *evidence*. • Given a description of *forces* on an object, *predict* the object's *motion*.*c
6-8 PS1D	The same unbalanced *force* will change the *motion* of an object with more *mass* more slowly than an object with less *mass*.	• Given two different *masses* that receive the same unbalanced *force*, *predict* which will move more quickly.

Mathematics Connections

*a	6.1.F	Fluidly and accurately multiply and divide non-negative decimals.
	6.2.E	Solve one-step equations and verify the solutions.
	6.2.F	Solve word problems using mathematical expressions and equations, and verify the solutions.
	6.3.B	Write ratios to represent a variety of rates.
	6.3.D	Solve single- and multi-step word problems involving ratios, rates, and percentages, and verify the solutions.
*b	5.5.C	Construct and interpret line graphs.
	7.5.A	Graph ordered pairs of rational numbers and determine the coordinates of a point in the coordinate plane.
*c	7.2.H	Determine whether or not a relationship is proportional and explain your reasoning.

EALR 4: **Physical Science**

Big Idea: **Matter: Properties and Change (PS2)**

Core Content: ***Atoms and Molecules***

In prior grades students learned the scientific meaning of the word matter, and about changes of state. In grades 6-8 students learn the basic concepts behind the atomic nature of matter. This includes the idea that elements are composed of a single kind of atom. Atoms chemically combine with each other or with atoms of other elements to form compounds. When substances are combined in physical mixtures, their chemical properties do not change; but when they combine chemically, the new product has different physical and chemical properties from any of the reacting substances. When substances interact in a closed system, the amount of mass does not change. Atomic theory also explains the ways that solids, liquids, and gases behave. These concepts about the nature of matter are fundamental to all sciences and technologies.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 PS2A	Substances have *characteristic intrinsic properties* such as *density*, *solubility*, *boiling point*, and *melting point*, all of which are independent of the amount of the sample.	• Use *characteristic intrinsic properties* such as *density*, *boiling point*, and *melting point* to identify an unknown substance.
6-8 PS2B	*Mixtures* are combinations of substances whose *chemical properties* are preserved. *Compounds* are substances that are chemically formed and have different physical and *chemical properties* from the reacting substances.	• Separate a *mixture* using differences in *properties* (e.g., *solubility*, size, magnetic attraction) of the substances used to make the *mixture*. • Demonstrate that the *properties* of a *compound* are different from the *properties* of the reactants from which it was formed.
6-8 PS2C	All *matter* is made of *atoms*. *Matter* made of only one type of *atom* is called an *element*.	• *Explain that* all *matter* is made of *atoms*, and give examples of *common elements*—substances composed of just one kind of *atom*.
6-8 PS2D	*Compounds* are composed of two or more kinds of *atoms*, which are bound together in well-defined *molecules* or crystals.	• Demonstrate with a labeled diagram and *explain* the *relationship* among *atoms*, *molecules*, *elements*, and *compounds*.
6-8 PS2E	*Solids*, *liquids*, and *gases* differ in the *motion* of individual particles. In *solids*, particles are packed in a nearly rigid structure; in *liquids*, particles move around one another; and in *gases*, particles move almost independently.	• *Describe* how *solids*, *liquids*, and *gases* behave when put into a container (e.g., a *gas* fills the entire volume of the container). Relate these *properties* to the relative movement of the particles in the three *states* of *matter*.
6-8 PS2F	When substances within a *closed system* interact, the total *mass* of the *system* remains the same. This *concept*, called *conservation of mass*, applies to all physical and *chemical changes*.	• *Apply* the *concept* of *conservation of mass* to correctly *predict* changes in *mass* before and after *chemical reactions*, including reactions that occur in closed containers, and reactions that occur in open containers where a *gas* is given off.*a

Mathematics Connections

*a	6.1.F	Solve word problems, using mathematical expressions and equations, and verify solutions.
	7.1.E	Solve two-step linear equations.

EALR 4: **Physical Science**

Big Idea: **Energy: Transfer, Transformation, and Conservation (PS3)**

Core Content: ***Interactions of Energy and Matter***

In prior grades students learned how heat, light, sound, and electrical energy are generated and can be transferred from place to place. In grades 6-8 students learn how energy and matter interact in various settings. Heat (thermal energy) always moves from a warmer to a cooler place through solids (by conduction) and through liquids and gases (mostly by convection or mechanical mixing). Light energy interacts with matter and with our eyes and allows us to see things. Electrical energy provides a convenient way to transfer energy to where and when the energy is needed. Sound is yet another form of energy produced by a vibrating object. These fundamental concepts of how matter and energy interact have broad application in all of the other sciences.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 PS3A	*Energy* exists in many forms which include: *heat*, light, chemical, electrical, *motion* of objects, and sound. *Energy* can be *transformed* from one *form* to another and *transferred* from one place to another.	• List different forms of *energy* (e.g., thermal, light, chemical, electrical, kinetic, and sound *energy*). • *Describe* ways in which *energy* is *transformed* from one *form* to another and *transferred* from one place to another (e.g., chemical to electrical *energy* in a battery, electrical to light *energy* in a bulb).
6-8 PS3B	*Heat* (thermal *energy*) flows from warmer to cooler objects until both reach the same *temperature*. *Conduction*, *radiation*, and *convection*, or *mechanical mixing*, are means of *energy transfer*.	• Use everyday examples of *conduction*, *radiation*, and *convection*, or *mechanical mixing*, to illustrate the *transfer* of *energy* from warmer objects to cooler ones until the objects reach the same *temperature*.
6-8 PS3C	*Heat* (thermal *energy*) consists of random *motion* and the vibrations of *atoms* and *molecules*. The higher the *temperature*, the greater the atomic or molecular *motion*. Thermal *insulators* are materials that resist the flow of *heat*.	• *Explain how* various types of insulation slow *transfer* of *heat energy* based on the atomic-molecular *model* of *heat* (thermal *energy*).
6-8 PS3D	Visible light from the Sun is made up of a mixture of all colors of light. To see an object, light emitted or reflected by that object must enter the eye.	• *Describe* how to demonstrate that visible light from the Sun is made up of different colors. • Draw and label a diagram showing that for an object to be seen, light must come directly from the object or from an external source reflected from the object, and enter the eye.
6-8 PS3E	*Energy* from a variety of sources can be transformed into electrical *energy*, and then to almost any other *form* of *energy*. Electricity can also be distributed quickly to distant locations.	• Illustrate the *transformations* of *energy* in an *electric circuit* when *heat*, light, and sound are produced. *Describe* the *transformation* of *energy* in a battery within an *electric circuit*.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
6-8 PS3F	*Energy* can be *transferred* from one place to another through *waves*. *Waves* include vibrations in materials. Sound and earthquake *waves* are examples. These and other *waves* move at different *speeds* in different materials.	• *Contrast* a light *wave* with a sound *wave* by identifying that both have *characteristic wavelengths*, but light *waves* can travel through a vacuum while sound *waves* cannot. • *Explain* that sound is caused by a vibrating object.

EALR 4: **Earth and Space Science**

Big Idea: **Earth in Space (ES1)**

Core Content: ***The Solar System***

In prior years, students learned the implications of the spherical-Earth concept and Earth's relationship to the Sun. In grades 6-8 students study the Moon's changing phases and learn to distinguish between phases and eclipses. They also learn about other objects in the Solar System and how they are held together by a force called "gravity." Students also learn about the Sun's position in the Milky Way, which is just one of many galaxies in the universe. This broad overview of Earth in space will provide a useful framework for students to understand new discoveries in astronomy and new milestones in the exploration of space.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 ES1A	The *Moon*'s monthly cycle of phases can be explained by its changing relative position as it *orbits* Earth. An *eclipse* of the *Moon* occurs when the *Moon* enters Earth's shadow. An *eclipse* of the Sun occurs when the *Moon* is between the Earth and Sun, and the *Moon*'s shadow falls on the Earth.	• Use a physical *model* or diagram to *explain how* the *Moon*'s changing position in its *orbit* results in the changing phases of the *Moon* as observed from Earth. • *Explain how* the cause of an *eclipse* of the *Moon* is different from the cause of the *Moon*'s phases.
6-8 ES1B	Earth is the third planet from the sun in a *system* that includes the *Moon*, the Sun, seven other major planets and their *moons*, and smaller objects such as *asteroids*, *plutoids*, *dwarf planets* and *comets*. These bodies differ in many *characteristics* (e.g., size, composition, relative position).	• *Compare* the relative sizes and distances of the Sun, *Moon*, Earth, other major *planets*, *moons*, *asteroids*, *plutoids*, and *comets*. *a
6-8 ES1C	Most objects in the *Solar System* are in regular and predictable *motion*. These *motion*s *explain* such *phenomena* as the day, the year, *phases of the Moon*, and *eclipses*.	• Use a simple physical *model* or labeled drawing of the Earth-Sun-*Moon system* to *explain* day and night, *phases of the Moon*, and *eclipses* of the *Moon* and Sun.
6-8 ES1D	*Gravity* is the *force* that keeps planets in *orbit* around the Sun and governs the rest of the *motion* in the *Solar System*. *Gravity* alone holds us to the Earth's surface.	• *Predict* what would happen to an *orbiting* object if *gravity* were increased, decreased, or taken away.
6-8 ES1E	Our Sun is one of hundreds of billions of stars in the Milky Way galaxy. Many of these stars have planets *orbiting* around them. The Milky Way galaxy is one of hundreds of billions of galaxies in the universe.	• Construct a physical *model* or diagram showing Earth's position in the *Solar System*, the *Solar System*'s position in the Milky Way, and the Milky Way among other galaxies.

Mathematics Connections

*a 7.2.D Make scale drawings and solve problems related to scale.

EALR 4: **Earth and Space Science**

Big Idea: **Earth Systems, Structures, and Processes (ES2)**

Core Content: ***Cycles in Earth Systems***

In prior grades students learned how Earth materials change and how they can be used for various purposes. In grades 6-8 students learn about planet Earth as an interacting system of solids, liquids, and gases. Solar energy powers the water cycle and drives the weather system and ocean currents. Energy from within the planet drives the rock cycle and moves huge plates on the Earth's surface, causing earthquakes and volcanoes. The landforms we see today result from processes that build up and break down Earth structures. These fundamental ideas will enable students to understand the history of their planet, Earth processes occurring today, and future geologic events.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 ES2A	The *atmosphere* is a *mixture* of nitrogen, oxygen, and trace *gases* that include *water vapor*. The *atmosphere* has different *properties* at different elevations.	• *Describe* the composition and *properties* of the troposphere and stratosphere.
6-8 ES2B	The Sun is the major source of *energy* for *phenomena* on Earth's surface, such as *winds*, ocean currents, and the water cycle.	• Connect the uneven heating of Earth's surface by the Sun to global *wind* and ocean currents. • *Describe* the role of the Sun in the water cycle.
6-8 ES2C	In the water cycle, water evaporates from Earth's surface, rises and cools, condenses to form clouds and falls as rain or snow and collects in bodies of water.	• *Describe* the water cycle and give local examples of where parts of the water cycle can be seen.
6-8 ES2D	Water is a solvent. As it passes through the water cycle, it dissolves minerals and *gases* and carries them to the oceans.	• Distinguish between bodies of saltwater and fresh water and *explain how* saltwater became salty.
6-8 ES2E	The *solid* Earth is composed of a relatively thin *crust*, a dense metallic *core*, and a layer called the *mantle* between the *crust* and *core* that is very hot and partially melted.	• Sketch and label the major layers of Earth, showing the approximate relative thicknesses and consistency of the *crust*, *core*, and *mantle*.*a
6-8 ES2F	The *crust* is composed of huge *crustal plates* on the scale of continents and oceans which move centimeters per year, pushed by *convection* in the upper *mantle*, causing earthquakes, volcanoes, and mountains.	• Draw a labeled diagram showing how *convection* in the upper *mantle* drives movement of *crustal plates*. • *Describe* what may happen when plate boundaries meet (e.g., earthquakes, *tsunami*, *faults*, mountain building), with examples from the Pacific Northwest.
6-8 ES2G	Landforms are created by processes that build up structures and processes that break down and carry away material through *erosion* and *weathering*.	• *Explain how* a given landform (e.g., mountain) has been shaped by processes that build up structures (e.g., uplift) and by processes that break down and carry away material (e.g., *weathering* and *erosion*).

	Content Standards	Performance Expectations
6-8 ES2H	The rock cycle *describes* the formation of *igneous rock* from magma or lava, *sedimentary* rock from compaction of eroded particles, and *metamorphic* rock by heating and pressure.	• Identify samples of *igneous*, *sedimentary*, and *metamorphic* rock from their *properties* and *describe* how their *properties* provide *evidence* of how they were formed. • *Explain how* one kind of rock could eventually become a different kind of rock.

Mathematics Connections

*a 7.2.D Make scale drawings and solve problems related to scale.

EALR 4: **Earth and Space Science**

Big Idea: **Earth History (ES3)**

Core Content: ***Evidence of Change***

In prior grades students learned that fossils provide evidence of environmental conditions that existed long ago. In grades 6-8 students learn a few of the methods that have made it possible to uncover the history of our planet. This history includes both slow, gradual changes and rapid, catastrophic events, such as an asteroid or comet striking the Earth. It is possible to read a great deal of that history from rocks, including layers of sedimentary rock, some of which contain fossils. Understanding Earth's history is a valuable complement to the study of biological evolution.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 ES3A	Our understanding of Earth history is based on the assumption that processes we see today are similar to those that occurred in the past.	• *Describe* Earth processes that we can observe and measure today (e.g., rate of *sedimentation*, movement of crustal plates, and changes in composition of the *atmosphere*) that provide clues to Earth's past.*a
6-8 ES3B	Thousands of layers of *sedimentary rock* provide *evidence* that allows us to determine the age of Earth's changing surface and to estimate the age of *fossils* found in the rocks.	• *Explain how* the age of landforms can be estimated by studying the number and thickness of rock layers, as well as *fossils* found within rock layers.
6-8 ES3C	In most locations *sedimentary* rocks are in horizontal formations with the oldest layers on the bottom. However, in some locations, rock layers are folded, tipped, or even inverted, providing *evidence* of geologic events in the distant past.	• *Explain why* younger layers of *sedimentary rocks* are usually on top of older layers, and *hypothesize* what geologic events could have caused huge blocks of horizontal *sedimentary* layers to be tipped or older rock layers to be on top of younger rock layers.
6-8 ES3D	Earth has been shaped by many natural catastrophes, including earthquakes, volcanic eruptions, glaciers, floods, storms, *tsunami*, and the impacts of *asteroid*s.	• *Interpret* current landforms of the Pacific Northwest as *evidence* of past geologic events (e.g., Mount St. Helens and Crater Lake provide *evidence* of volcanism, the Channeled Scablands provides *evidence* of floods that resulted from melting of glaciers).
6-8 ES3E	Living *organisms* have played several critical roles in shaping landforms that we see today.	• List several ways that living *organisms* have shaped landforms (e.g., coral islands, limestone deposits, oil and coal deposits).

Mathematics Connections

*a	6.3.B	Write ratios to represent a variety of rates.

EALR 4: **Life Science**

Big Idea: **Structure and Function of Living Organisms (LS1)**

Core Content: ***From Cells to Organisms***

In prior grades students learned how structures in the body work together to respond to internal and external needs. In grades 6-8 students learn that all living systems are composed of cells which make up tissues, organs, and organ systems. At each level of organization, the structures enable specific functions required by the organism. Lifestyle choices and environmental conditions can affect parts of the human body, which may affect the health of the body as a whole. Understanding how organisms operate as systems helps students understand the commonalities among life forms, provides an introduction to further study of biology, and offers scientific insights into the ways that personal choices may affect health.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 LS1A	All *organisms* are composed of cells, which carry on the many *functions* needed to sustain life.	• Draw and *describe observations* made with a microscope showing that plants and animals are made of cells, and *explain that* cells are the fundamental unit of life. • *Describe* the *functions* performed by cells to sustain a living *organism* (e.g., division to produce more cells, taking in *nutrients*, releasing waste, using *energy* to do work, and producing materials the *organism* needs).
6-8 LS1B	One-celled *organisms* must contain parts to carry out all life *functions*.	• Draw and *describe observations* made with a microscope showing that a single-celled *organism* (e.g., paramecium) contains parts used for all life *functions.*
6-8 LS1C	Multicellular *organisms* have specialized cells that perform different *functions*. These cells join together to *form* tissues that give organs their structure and enable the organs to perform specialized *functions* within organ *systems*.	• Relate the structure of a specialized cell (e.g., nerve and muscle cells) to the *function* that the cell performs. • *Explain* the *relationship* between tissues that make up individual organs and the *functions* the organ performs (e.g., valves in the heart *control* blood flow, *air* sacs in the lungs maximize surface area for *transfer* of *gases*). • *Describe* the components and *functions* of the digestive, circulatory, and respiratory *systems* in humans and how these systems interact.
6-8 LS1D	Both plant and animal cells must carry on life *functions*, so they have parts in *common*, such as *nuclei*, cytoplasm, *cell membranes*, and *mitochondria*. But plants have specialized cell parts, such as *chloroplasts* for photosynthesis and cell walls, which provide plants their overall structure.	• Use labeled diagrams or *models* to illustrate similarities and differences between plant and animal cell structures and *describe* their functions (e.g., both have nuclei, cytoplasm, *cell membranes*, and *mitochondria*, while only plants have *chloroplasts* and cell walls).
6-8 LS1E	In classifying *organisms*, scientists *consider* both internal and external structures and behaviors.	• Use a classification key to identify *organisms*, noting use of both internal and external structures as well as behaviors.

	Content Standards	Performance Expectations
6-8 LS1F	Lifestyle choices and living *environments* can damage structures at any level of organization of the human body and can significantly harm the whole *organism*.	• *Evaluate* how lifestyle choices and *environments* (e.g., tobacco, drug, and alcohol use, amount of exercise, quality of *air*, and kinds of food) affect parts of the human body and the *organism* as a whole.

EALR 4: **Life Science**

Big Idea: **Ecosystems (LS2)**

Core Content: ***Flow of Energy Through Ecosystems***

In prior grades students learned how ecosystems change and how these changes affect the capacity of an ecosystem to support populations. In grades 6-8 students learn to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. Essential concepts include the process of photosynthesis used by plants to transform the energy of sunlight into food energy, which is used by other organisms, and possible causes of environmental change. Students also learn to investigate environmental issues and to use science to evaluate different solutions to problems. Knowledge of how energy flows through ecosystems is a critical aspect of students' understanding of how energy sustains life on the planet, including human life.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 LS2A	An *ecosystem* consists of all the *populations* living within a specific area and the nonliving *factors* they interact with. One geographical area may contain many *ecosystems*.	• *Explain that* an *ecosystem* is a defined area that contains *populations* of *organisms* and nonliving *factors*. • Give examples of *ecosystems* (e.g., Olympic National Forest, Puget Sound, one square foot of lawn) and *describe* their boundaries and contents.
6-8 LS2B	*Energy* flows through an *ecosystem* from *producers* (plants) to *consumers* to *decomposers*. These *relationships* can be shown for specific *populations* in a *food web*.	• *Analyze* the flow of *energy* in a local *ecosystem*, and draw a labeled *food web* showing the *relationships* among all of the *ecosystem*'s plant and animal *populations*.
6-8 LS2C	The major source of *energy* for *ecosystems* on Earth's surface is sunlight. *Producers transform* the *energy* of sunlight into the chemical *energy* of food through *photosynthesis*. This food *energy* is used by plants, and all other *organisms* to carry on life processes. Nearly all *organisms* on the surface of Earth depend on this *energy* source.	• *Explain how energy* from the Sun is *transformed* through *photosynthesis* to produce chemical *energy* in food. • *Explain that producers* are the only *organisms* that make their own food. Animals cannot survive without *producers* because animals get food by eating *producers* or other animals that eat *producers*.
6-8 LS2D	*Ecosystems* are continuously changing. Causes of these changes include nonliving *factors* such as the amount of light, range of *temperatures*, and availability of water, as well as living *factors* such as the disappearance of different *species* through disease, predation, *habitat* destruction and overuse of resources or the introduction of new *species*.	• *Predict* what may happen to an *ecosystem* if nonliving *factors* change (e.g., the amount of light, range of *temperatures*, or availability of water or *habitat*), or if one or more *populations* are removed from or added to the *ecosystem*.

	Content Standards	Performance Expectations
6-8 LS2E	*Investigation*s of *environmental* issues should uncover *factors* causing the problem and relevant scientific *concepts* and findings that may inform an *analysis* of different ways to address the issue.	• *Investigate* a local *environmental* issue by defining the problem, researching possible causative *factors*, understanding the underlying *science*, and evaluating the benefits and risks of alternative *solutions.* • Identify resource uses that reduce the capacity of *ecosystems* to support various *populations* (e.g., use of pesticides, construction).

EALR 4: **Life Science**

Big Idea: **Biological Evolution (LS3)**

Core Content: ***Inheritance, Variation, and Adaptation***

In prior years, students learned that differences in inherited characteristics might help organisms survive and reproduce. In grades 6-8 students learn how the traits of organisms are passed on through the transfer of genetic information during reproduction and how inherited variations can become adaptations to a changing environment. Sexual reproduction produces variations because genes are inherited from two parents. Variations can be either physical or behavioral, and some have adaptive value in a changing environment. In the theory of biological evolution the processes of inheritance, variation, and adaptation explain both the diversity and unity of all life.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
6-8 LS3A	The scientific *theory* of *evolution* underlies the study of biology and explains both the *diversity* of life on Earth and similarities of all *organisms* at the chemical, cellular, and molecular level. *Evolution* is supported by multiple forms of scientific *evidence*.	• *Explain* and provide *evidence* of how biological *evolution* accounts for the *diversity* of *species* on Earth today.
6-8 LS3B	Every *organism* contains a set of *genetic information* (instructions) to specify its traits. This information is contained within *genes* in the *chromosomes* in the *nucleus* of each cell.	• *Explain that* information on how cells are to grow and *function* is contained in *genes* in the *chromosomes* of each cell *nucleus* and that during the process of reproduction the *genes* are passed from the parent cells to offspring.
6-8 LS3C	Reproduction is essential for every *species* to continue to exist. Some plants and animals reproduce sexually while others reproduce *asexually*. *Sexual reproduction* leads to greater *diversity* of *characteristics* because offspring inherit *genes* from both parents.	• Identify sexually and asexually reproducing plants and animals. • *Explain* why offspring that result from *sexual reproduction* are likely to have more diverse *characteristics* than offspring that result from *asexual reproduction*.
6-8 LS3D	In *sexual reproduction* the new *organism* receives half of its *genetic information* from each parent, resulting in offspring that are similar but not identical to either parent. In *asexual reproduction* just one parent is involved, and *genetic information* is passed on *nearly unchanged.*	• *Describe* that in *sexual reproduction* the offspring receive *genetic information* from both parents, and therefore differ from the parents. • *Predict* the outcome of specific *genetic* crosses involving one *characteristic* (using *principles* of *Mendelian* genetics). • *Explain* the survival value of *genetic variation.*
6-8 LS3E	*Adaptations* are physical or behavioral changes that are inherited and enhance the ability of an *organism* to survive and reproduce in a particular *environment.*	• Give an example of a plant or animal *adaptation* that would confer a survival and reproductive advantage during a given *environmental* change.
6-8 LS3F	*Extinction* occurs when the *environment* changes and the adaptive *characteristics* of a *species*, including its behaviors, are insufficient to allow its survival.	• Given an *ecosystem, predict* which *organisms* are most likely to disappear from that *environment* when the *environment* changes in specific ways.

	Content Standards	Performance Expectations
6-8 LS3G	*Evidence* for *evolution* includes similarities among anatomical and cell structures, and *patterns* of development make it possible to *infer* degree of relatedness among *organisms*.	• *Infer* the degree of relatedness of two *species*, given diagrams of *anatomical feature*s of the two *species* (e.g., chicken wing, whale flipper, human hand, bee leg).

Science Standards
Grades 9-12

In support of the recommendation by the State Board of Education that all students take at least three years of high school science, nine Core Content Standards are given for grades 9-11. Only three of these Core Content Standards need to be learned ***in depth*** each year. Local school district curriculum teams will decide which of the areas will be learned in grades 9, 10, and 11, depending on students' needs and interests.

Recognizing that many students will take a fourth year of science, standards for crosscutting concepts and abilities apply to all four years of science, grades 9-12. The skills and abilities found in the crosscutting concepts are essential for all students, whether attending college, technical schools, an apprenticeship program, or entering the world of work; hence their inclusion in grades 9-12. Specific content domain standards are not delineated in grade 12 to allow for flexibility in high school course offerings.

As illustrated by the grid below, the three crosscutting EALRs of Systems, Inquiry, and Application are not to be learned in isolation, but rather in conjunction with content in the science domains. Not every topic needs to address all three crosscutting EALRs. But in any given unit, content in Systems, Inquiry, and Application should be experienced in the context of several science lessons so that students can see the commonalities among the domains of science while continuing to learn the fundamental procedural underpinnings that cut across all of the sciences.

Grades 9-12 **EALR 4 Domains of Science**	**EALR 1** **Systems** **SYS**	**EALR 2** **Inquiry** **INQ**	**EALR 3** **Application** **APP**
Physical Science PS1 Newton's Laws PS2 Chemical Reactions PS3 Transformation and Conservation of Energy **Earth and Space Science** ES1 Evolution of the Universe ES2 Energy in Earth Systems ES3 Evolution of the Earth **Life Science** LS1 Processes Within Cells LS2 Maintenance and Stability of Populations LS3 Mechanisms of Evolution	Predictability and Feedback	Conducting Analyses and Thinking Logically	Science, Technology, and Society

EALR 1: **Systems**

Big Idea: **Systems (SYS)**

Core Content: ***Predictability and Feedback***

In prior grades students learned how to simplify and analyze complex situations by thinking about them as systems. In grades 9-12 students learn to construct more sophisticated system models, including the concept of feedback. Students are expected to determine whether or not systems analysis will be helpful in a given situation and if so, to describe the system, including subsystems, boundaries, flows, and feedbacks. The next step is to use the system as a dynamic model to predict changes. Students are also expected to recognize that even the most sophisticated models may not accurately predict how the real world functions. This deep understanding of systems and ability to use systems analysis is an essential tool both for scientific inquiry and for technological design.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-12 SYSA	*Feedback* is a process in which the *output* of a *system* provides information used to regulate the operation of the *system*. Positive *feedback* increases the disturbance to a *system*. Negative *feedback* reduces the disturbance to a *system*.	• Give examples of a positive *feedback system* and *explain* its regulatory mechanism (e.g., global warming causes Earth's ice caps to melt, reflecting less *energy* to space, increasing *temperatures*).*a • Give examples of a negative *feedback system* and *explain* its regulatory mechanism (e.g., when a human body overheats, it produces sweat that cools the body by *evaporation*).*a
9-12 SYSB	*Systems* thinking can be especially useful in *analyzing* complex situations. To be useful, a *system* needs to be specified as clearly as possible.	• Determine if a *systems* approach will be helpful in answering a *question* or solving a problem.*b • Represent the *system* with a diagram specifying components, boundaries, flows, and *feedbacks*.*a • *Describe* relevant *subsystems* and the larger *system* that contains the *system* being analyzed.*a • Determine how the *system functions* with respect to other *systems*.
9-12 SYSC	In complex *systems*, entirely new and unpredictable *properties* may emerge. Consequently, modeling a complex *system* in sufficient detail to make *reliable predictions* may not be possible.	• Create a simplified *model* of a complex *system*. Trace the possible consequences of a change in one part of the *system* and *explain how* the simplified *model* may not be adequate to reliably *predict* consequences.
9-12 SYSD	*Systems* can be changing or in *equilibrium*.	• *Analyze* whether or not a *system* (e.g., population) is changing or in *equilibrium*. *c • Determine whether a *state of equilibrium* is static or dynamic (e.g., inflows equal outflows). *c

Mathematics Connections

*a	A1.8.A	Analyze a problem situation and represent it mathematically.
	A1.1.A	Select and justify functions and equations to model and solve problems.
*b	A1.8.B	Select and apply strategies to solve problems.
	A1.8.D	Generalize a solution strategy for a single problem to a class of related problems, and apply a strategy for a class of related problems to solve a specific problem.
*c	A1.8.H	Use inductive reasoning about algebra and the properties of numbers to make conjectures, and use deductive reasoning to prove or disprove conjectures.
	A1.7.C	Express arithmetic and geometric sequences in explicit and recursive forms, translate between the two forms, explain how rate of change is represented in each form, and use the forms to find specific terms in the sequence.

EALR 2: **Inquiry**

Big Idea: **Inquiry (INQ)**

Core Content: ***Conducting Analyses and Thinking Logically***

In prior grades students learned to revise questions so they can be answered scientifically. In grades 9-12 students extend and refine their understanding of the nature of inquiry and their ability to formulate questions, propose hypotheses, and design, conduct, and report on investigations. Refinement includes an increased understanding of the kinds of questions that scientists ask and how the results reflect the research methods and the criteria that scientific arguments are judged by. Increased abilities include competence in using mathematics, a closer connection between student-planned investigations and existing knowledge, improvements in communication and collaboration, and participation in a community of learners.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-12 INQA Question	Scientists *generate* and *evaluate questions* to *investigate* the *natural world*.	• *Generate* and *evaluate* a *question* that can be answered through a scientific *investigation*. Critique *questions generated* by others and *explain* whether or not the *questions* are scientific.*a
9-12 INQB Investigate	Scientific progress requires the use of various methods appropriate for answering different kinds of research *questions*, a thoughtful plan for gathering data needed to answer the *question*, and care in collecting, *analyzing*, and displaying the data.	• Plan and conduct a scientific *investigation*, choosing a method appropriate to the *question* being asked. • Collect, *analyze*, and display data using calculators, computers, or other technical devices when available.*b
9-12 INQC Explain	*Conclusions* must be logical, based on *evidence*, and consistent with prior *established* knowledge.	• Draw *conclusions* supported by *evidence* from the *investigation* and consistent with *established* scientific knowledge.*c • Analyze alternative explanations and decide which best fits the data and *evidence*.*d
9-12 INQD Communicate Clearly	The methods and procedures that scientists use to obtain *evidence* must be clearly reported to enhance opportunities for further *investigation*.	• Write a detailed laboratory report that includes: the *question* that motivated the study, a justification for the kind of *investigation* chosen, *hypotheses* (if any), a description of what was done, a summary of data in tables and graphs, and a *conclusion*, based on the *evidence*, that responds to the *question*.
9-12 INQE Model	The essence of scientific *investigation* involves the development of a *theory* or conceptual *model* that can *generate* testable predictions.	• Formulate one or more *hypotheses* based on a *model* or *theory* of a causal *relationship*. Demonstrate creativity and critical thinking to formulate and *evaluate* the *hypotheses*.
9-12 INQF Communicate	*Science* is a human endeavor that involves logical reasoning and creativity and entails the testing, revision, and occasional discarding of theories as new *evidence* comes to light.	• *Evaluate* an *investigation* to determine if it was a *valid* means of answering the *question*, and whether or not the results were *reliable*. *e • *Describe* the development of a scientific *theory* that illustrates logical reasoning, creativity, testing, revision, and replacement of prior *ideas* in light of new *evidence*.

	Content Standards	Performance Expectations
9-12 INQG Intellectual Honesty	Public *communication* among scientists is an essential aspect of research. Scientists *evaluate* the *validity* of one another's *investigation*s, check the *reliability* of results, and *explain* inconsistencies in findings.	• Participate in a scientific discussion about one's own *investigation*s and those performed by others. • Respond to *questions* and criticisms, and if appropriate, revise explanations based on these discussions.
9-12 INQH Intellectual Honesty	Scientists carefully *evaluate* sources of information for *reliability* before using that information. When referring to the *ideas* or findings of others, they cite their sources of information.	• Provide appropriate citations for all *ideas*, findings, and information used in any and all written reports. • *Explain* the consequences for failure to provide appropriate citations.

Mathematics Connections

*a	8.5.H	Make and test conjectures based on data or information collected from explorations and experiments.
*b	8.5.D	Represent a problem situation, describe the process used to solve the problem, and verify the reasonableness of the solution.
	A1.8.A	Analyze a problem situation and represent it mathematically.
	A2.1.A	Select and justify functions and equations to model and solve problems.
	A2.6.F	Calculate and interpret measures of variability and standard deviation, and use these measures to describe and *compare* data sets.
	A1.8.F	Summarize mathematical ideas with precision and efficiency for a given audience and purpose.
	A1.6.E	Describe the correlation of data in scatter plots in terms of strong or weak and positive or negative.
*c	A1.6.B	Make valid inferences and draw conclusions based on data.
	A1.8.G	Synthesize information to draw conclusions and evaluate the arguments and conclusions of others.
*d	A1.6.D	Find the equation of a linear function that best fits bivariate data that are linearly related, interpret the slope and the y-intercept of the line, and use the equation to make predictions.
	A1.8.H	Use inductive reasoning about algebra and the properties of numbers to make conjectures, and use deductive reasoning to prove or disprove conjectures.
*e	G.7.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret it in the context of the original problem.
	A1.8.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret the solution in the context of the original problem.

Note: This standard is closely aligned to Mathematics Core Processes A1.8 and G.7.

Standards for Grades 9-12

EALR 3: **Application**

Big Idea: **Application (APP)**

Core Content: ***Science, Technology, and Society***

In prior grades students learn to work with other members of a team to apply the full process of technological design and relevant science concepts to solve problems. In grades 9-12 students apply what they have learned to address societal issues and cultural differences. Students learn that science and technology are interdependent, that science and technology influence society, and that society influences science and technology. Students continue to increase their abilities to work with other students and to use mathematics and information technologies (when available) to solve problems. They transfer insights from those increased abilities when considering local, regional, and global issues. These insights and capabilities will help prepare students to solve societal and personal problems in future years.

	Content Standards	Performance Expectations
	Students know that:	*Students are expected to:*
9-12 APPA	*Science* affects society and *cultures* by influencing the way many people think about themselves, others, and the *environment*. Society also affects *science* by its prevailing views about what is important to study and by deciding what research will be funded.	• *Describe* ways that scientific *ideas* have influenced society or the development of differing *cultures*. • List *questions* that scientists *investigate* that are stimulated by the needs of society (e.g., medical research, *global climate* change).
9-12 APPB	The *technological design process* begins by defining a problem in terms of *criteria* and *constraints*, conducting research, and generating several different *solutions.*	• Work collaboratively with other students to *generate ideas* for solving a problem. Identify *criteria* and *constraints*, research the problem, and *generate* several possible *solutions*.
9-12 APPC	Choosing the best *solution* involves comparing alternatives with respect to *criteria* and *constraints*, then building and testing a *model* or other representation of the final design.	• Choose the best *solution* for a problem, create a *model* or drawing of the final design, and devise a way to test it. Redesign the *solution*, if necessary, then present it to peers.*b
9-12 APPD	The ability to solve problems is greatly enhanced by use of mathematics and information technologies.	• Use proportional reasoning, functions, graphing, and estimation to solve problems.*a*b*c • Use computers, probes, and software when available to collect, display, and analyze data.
9-12 APPE	Perfect *solutions* do not exist. All technological *solutions* involve trade-offs in which decisions to include more of one quality means less of another. All *solutions* involve consequences, some intended, others not.	• *Analyze* a societal issue that may be addressed through *science* and/or *technology*. *Compare* alternative *solutions* by *considering trade-offs* and unintended consequences (e.g., removing dams to increase salmon spawning).
9-12 APPF	It is important for all citizens to *apply science* and *technology* to critical issues that influence society.	• Critically *analyze* scientific information in current events to make personal choices or to understand public-policy decisions.*d

Mathematics Connections

*a	A1.8.A	Analyze a problem situation and represent it mathematically.
*b	A1.8.C	Evaluate a solution for reasonableness, verify its accuracy, and interpret it in the context of the original problem.
*c	A1.3B.	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
*d	A1.8.G	Synthesize information to draw conclusions and evaluate the arguments and conclusions of others.

EALR 4: **Physical Science**

Big Idea: **Force and Motion (PS1)**

Core Content: ***Newton's Laws***

In prior grades students learned to measure, record, and calculate the average speed of objects, and to tabulate and graph the results. In grades 9-11 students learn to apply Newton's Laws of Motion and Gravity both conceptually and quantitatively. Students are able to calculate average speed, velocity, and acceleration. Students also develop an understanding of forces due to gravitational and electrical attraction. These fundamental concepts enable students to understand the forces that govern the observable world and provide a foundation for a full course in physics.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 PS1A	*Average velocity* is defined as a change in position with respect to time. *Velocity* includes both *speed* and direction.	• Calculate the *average velocity* of a moving object, given the object's change in position and time. ($v = x_2\text{-}x_1/\ t_2\text{-}t_1$) *a • *Explain how* two objects moving at the same *speed* can have different velocities.
9-11 PS1B	*Average acceleration* is defined as a change in *velocity* with respect to time. *Acceleration* indicates a change in *speed* and/or a change in direction.	• Calculate the *average acceleration* of an object, given the object's change in *velocity* with respect to time. ($a = v_2\text{-}v_1/\ t_2\text{-}t_1$) *a • *Explain how* an object moving at constant *speed* can be *accelerating.* *b
9-11 PS1C	An object at rest will remain at rest unless acted on by an unbalanced *force*. An object in *motion* at constant *velocity* will continue at the same *velocity* unless acted on by an unbalanced *force*. (Newton's First Law of Motion, the Law of Inertia)	• Given specific scenarios, *compare* the *motion* of an object acted on by balanced *forces* with the *motion* of an object acted on by unbalanced *forces.*
9-11 PS1D	A net *force* will cause an object to *accelerate* or change direction. A less massive object will *speed* up more quickly than a more massive object subjected to the same *force*. (Newton's Second Law of Motion, F=ma)	• *Predict* how objects of different *masses* will *accelerate* when subjected to the same *force.* • Calculate the *acceleration* of an object, given the object's *mass* and the net *force* on the object, using Newton's Second Law of Motion (F=ma).*c
9-11 PS1E	Whenever one object exerts a *force* on another object, a *force* of equal magnitude is exerted on the first object in the opposite direction. (Newton's Third Law of Motion)	• Illustrate with everyday examples that for every action there is an equal and opposite reaction (e.g., a person exerts the same *force* on the Earth as the Earth exerts on the person).
9-11 PS1F	*Gravitation* is a universal attractive *force* by which objects with *mass* attract one another. The gravitational *force* between two objects is proportional to their *masses* and inversely proportional to the square of the distance between the objects. (Newton's *Law* of Universal Gravitation)	• *Predict* how the gravitational *force* between two bodies would differ for bodies of different *masses* or different distances apart.*d • *Explain how* the *weight* of an object can change while its *mass* remains constant.

	Content Standards	Performance Expectations
9-11 PS1G	Electrical *force* is a *force* of nature independent of *gravity* that exists between charged objects. Opposite charges attract while like charges repel.	• *Predict* whether two charged objects will attract or repel each other, and *explain* why.
9-11 PS1H	Electricity and magnetism are two aspects of a single *electromagnetic force*. Moving electric charges produce magnetic *forces*, and moving magnets produce electric *forces*.	• Demonstrate and *explain that* an electric current flowing in a wire will create a magnetic field around the wire (electromagnetic effect). • Demonstrate and *explain that* moving a magnet near a wire will cause an electric current to flow in the wire (the generator effect).

Mathematics Connections

*a	7.2.E	Represent proportional relationships using graphs, tables, and equations, and make connections among the representations.
	7.2.F	Determine the slope of a line corresponding to the graph of a proportional relationship, and relate slope to similar triangles.
	A1.3.B	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
	A1.4.C	Identify and interpret the slopes and intercepts of a linear function, including equations for parallel and perpendicular lines.
	A1.2.B	Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
	A1.8.A	Analyze a problem situation and represent it mathematically.
*b	A1.4.C	Identify and interpret the slopes and intercepts of a linear function, including equations for parallel and perpendicular lines.
	A1.2.B	Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
*c	7.2.E	Represent proportional relationships, using graphs, tables, and equations, and make connections among the representations.
	A1.6.B	Make valid inferences and draw conclusions based on data.
	A1.2.B	Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
	A1.7.D	Solve an equation involving several variables by expressing one variable in terms of the others.
*d	A1.3.B	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
	A1.6.B	Make valid inferences and draw conclusions based on data.
	A1.7.D	Solve an equation involving several variables by expressing one variable in terms of the others.

EALR 4: **Physical Science**

Big Idea: **Matter: Properties and Change (PS2)**

Core Content: ***Chemical Reactions***

In prior years, students learned the basic concepts behind the atomic nature of matter. In grades 9-11 students learn about chemical reactions, starting with the structure of an atom. They learn that the Periodic Table groups elements with similar physical and chemical properties. With grounding in atomic structure, students learn about the formation of molecules and ions, compounds and solutions, and the details of a few common chemical reactions. They also learn about nuclear reactions and the distinction between fusion and fission. These concepts about the fundamental properties of matter will help students understand chemical and nuclear reactions that are important in modern society and lay the groundwork for both chemistry and life science.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 PS2A	*Atoms* are composed of *proton*s, *neutrons*, and *electrons*. The *nucleus* of an *atom* takes up very little of the *atom*'s volume but makes up almost all of the *mass*. The *nucleus* contains *protons* and *neutrons*, which are much more massive than the *electrons* surrounding the *nucleus*. *Protons* have a positive charge, *electrons* are negative in charge, and *neutrons* have no net charge.	• *Describe* the relative charges, *masses*, and locations of the *protons*, *neutrons*, and *electrons* in an *atom* of an *element*.
9-11 PS2B	*Atoms* of the same *element* have the same number of *protons*. The number and arrangement of *electrons* determines how the *atom* interacts with other *atoms* to *form molecules* and *ionic crystals.*	• Given the number and arrangement of *electrons* in the outermost shell of an *atom*, *predict* the *chemical properties* of the *element*.
9-11 PS2C	When *elements* are listed in order according to the number of *protons*, repeating *patterns* of physical and *chemical properties* identify families of *elements* with similar *properties.* This Periodic Table is a consequence of the repeating *pattern* of outermost *electrons.*	• Given the number of *protons*, identify the *element* using a Periodic Table. • *Explain* the arrangement of the *elements* on the Periodic Table, including the significant *relationships* among *elements* in a given column or row.
9-11 PS2D	*Ions* are produced when *atoms* or *molecules* lose or gain *electrons*, thereby gaining a positive or negative electrical charge. *Ions* of opposite charge are attracted to each other, forming *ionic bonds.* Chemical formulas for *ionic compounds* represent the proportion of *ion* of each *element* in the *ionic crystal*.	• *Explain how ions* and *ionic bonds* are formed (e.g., sodium *atoms* lose an *electron* and chlorine *atoms* gain an *electron*, then the charged *ions* are attracted to each other and *form* bonds). • *Explain* the meaning of a chemical formula for an *ionic crystal* (e.g., NaCl).
9-11 PS2E	*Molecular compounds* are composed of two or more *elements* bonded together in a fixed proportion by sharing *electrons* between *atoms*, forming *covalent bond*s. Such *compounds* consist of well-defined *molecules.* Formulas of *covalent compounds* represent the types and number of *atoms* of each *element* in each *molecule.*	• Give examples to illustrate that *molecules* are groups of two or more *atoms* bonded together (e.g., a *molecule* of water is formed when one oxygen *atom* shares *electrons* with two hydrogen *atoms*). • *Explain* the meaning of a chemical formula for a *molecule* (e.g., CH_4 or H_2O).*a

	Content Standards	Performance Expectations
9-11 PS2F	All forms of life are composed of large *molecules* that contain carbon. Carbon *atoms* bond to one another and other *elements* by sharing electrons, forming *covalent bond*s. Stable *molecules* of carbon have four *covalent bond*s per carbon *atom*.	• Demonstrate how carbon *atoms form* four *covalent bond*s to make large *molecules*. Identify the *functions* of these *molecules* (e.g., plant and animal tissue, polymers, sources of food and nutrition, *fossil fuels*).
9-11 PS2G	*Chemical reactions* change the arrangement of *atoms* in the *molecules* of substances. *Chemical reactions* release or acquire *energy* from their surroundings and result in the formation of new substances.	• *Describe* at least three *chemical reactions* of particular importance to humans (e.g., burning of *fossil fuels*, *photosynthesis*, rusting of metals). • Use a chemical equation to illustrate how the *atoms* in *molecules* are arranged before and after a reaction. • Give examples of *chemical reactions* that either release or acquire *energy* and result in the formation of new substances (e.g., burning of *fossil fuels* releases large amounts of *energy* in the form of *heat*).
9-11 PS2H	*Solutions* are *mixtures* in which particles of one substance are evenly distributed through another substance. *Liquids* are limited in the amount of dissolved *solid* or *gas* that they can contain. *Aqueous solutions* can be *described* by relative quantities of the dissolved substances and acidity or alkalinity (pH).	• Give examples of *common solutions*. *Explain* the differences among the processes of dissolving, melting, and reacting. • *Predict* the result of adding increased amounts of a substance to an *aqueous solution*, in concentration and pH.*b
9-11 PS2I	The rate of a physical or *chemical change* may be affected by *factors* such as *temperature*, surface area, and pressure.	• *Predict* the *effect* of a change in *temperature*, surface area, or pressure on the rate of a given physical or *chemical change*.*b
9-11 PS2J	The number of *neutrons* in the *nucleus* of an *atom* determines the *isotope* of the *element*. Radioactive *isotopes* are unstable and emit particles and/or *radiation*. Though the timing of a single nuclear decay is unpredictable, a large group of nuclei decay at a predictable rate, making it possible to estimate the age of materials that contain radioactive *isotopes*.	• Given the *atomic number* and *atomic mass number* of an *isotope*, students draw and label a *model* of the *isotope's* atomic structure (number of *protons*, *neutrons*, and *electrons*). • Given data from a sample, use a decay curve for a radioactive *isotope* to find the age of the sample. *Explain how* the decay curve is derived. *c
9-11 PS2K	Nuclear reactions convert *matter* into *energy*, releasing large amounts of *energy compare*d with *chemical reactions*. *Fission* is the splitting of a large *nucleus* into smaller pieces. *Fusion* is the joining of nuclei and is the process that *generates energy* in the Sun and other stars.	• Distinguish between nuclear *fusion* and nuclear *fission* by describing how each process *transform*s *elements* present before the reaction into *elements* present after the reaction.

Mathematics Connections

*a	G.3.J	Describe prisms, pyramids, parallelepipeds, tetrahedra, and regular polyhedra in terms of their faces, edges, vertices, and properties.
*b	7.2.E	Represent proportional relationships, using graphs, tables, and equations, and make connections among the representations.
*c	A1.1.A	Select and justify functions and equations to model and solve problems.
	A1.7.A	Sketch the graph for an exponential function of the form $y = ab^n$ where n is an integer, describe the effects that changes in the parameters a and b have on the graph, and answer questions that arise in situations modeled by exponential functions.
	A1.7.B	Find the approximate solutions to exponential equations.

EALR 4: **Physical Science**

Big Idea: **Energy: Transfer, Transformation, and Conservation (PS3)**

Core Content: ***Transformation and Conservation of Energy***

In prior grades students learned to apply the concept of "energy" in various settings. In grades 9-11 students learn fundamental concepts of energy, including the Law of Conservation of Energy—that the total amount of energy in a closed system is constant. Other key concepts include gravitational potential and kinetic energy, how waves transfer energy, the nature of sound, and the electromagnetic spectrum. Energy concepts are essential for understanding all of the domains of science (EALR 4), from the ways that organisms get energy from their environment, to the energy that drives weather systems and volcanoes.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 PS3A	Although *energy* can be *transferred* from one object to another and can be *transformed* from one form of *energy* to another *form*, the total *energy* in a *closed system* remains the same. The *concept* of *conservation of energy*, applies to all physical and chemical changes.	• *Describe* a situation in which *energy* is *transferred* from one place to another and *explain how energy* is conserved.*a • *Describe* a situation in which *energy* is *transformed* from one *form* to another and *explain how energy* is conserved.*a
9-11 PS3B	*Kinetic energy* is the *energy* of *motion*. The kinetic *energy* of an object is defined by the equation: $E_k = \frac{1}{2} mv^2$	• Calculate the *kinetic energy* of an object, given the object's *mass* and *velocity*. *b
9-11 PS3C	*Gravitational potential energy* is due to the separation of mutually attracting *masses*. *Transformations* can occur between *gravitational potential energy* and *kinetic energy*, but the total amount of *energy* remains constant.	• Give an example in which *gravitational potential energy* and *kinetic energy* are changed from one to the other (e.g., a child on a swing illustrates the alternating *transformation* of *kinetic* and *gravitational potential energy*).
9-11 PS3D	*Waves* (including sound, seismic, light, and water *waves*) *transfer energy* when they interact with *matter*. *Waves* can have different *wavelengths, frequencies*, and *amplitudes*, and travel at different *speeds*.	• Demonstrate how *energy* can be transmitted by sending *waves* along a spring or rope. Characterize physical *waves* by *frequency, wavelength, amplitude*, and *speed*. • *Apply* these *properties* to the pitch and volume of sound *waves* and to the *wavelength* and magnitude of water *waves*.*b
9-11 PS3E	*Electromagnetic waves* differ from physical *waves* because they do not require a medium and they all travel at the same *speed* in a vacuum. This is the maximum *speed* that any object or *wave* can travel. Forms of *electromagnetic waves* include X-rays, ultraviolet, visible light, infrared, and radio.	• Illustrate the *electromagnetic spectrum* with a labeled diagram, showing how regions of the spectrum differ regarding *wavelength, frequency*, and *energy*, and how they are used (e.g., infrared in *heat* lamps, microwaves for heating foods, X-rays for medical imaging).

Mathematics Connections

*a	G.6.F	Solve problems involving measurement conversions within and between systems, including those involving derived units, and analyze solutions in terms of reasonableness of solutions and appropriate units.
*b	A1.2.B	Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
	A1.7.D	Solve an equation involving several variables by expressing one variable in terms of the others.

EALR 4: **Earth and Space Science**

Big Idea: **Earth in Space (ES1)**

Core Content: ***Evolution of the Universe***

In prior grades students learned about other objects in the Solar System and how they are held together by a force called "gravity." In grades 9-11 students learn the current scientific theory about the origin of the universe and subsequent formation of our Solar System. These discoveries are based on the important concept that the physical principles that apply today on Earth apply everywhere in the universe, now and in the distant past. These fundamental concepts help students make coherent sense of the universe and engage in further wondering and learning.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 ES1A	Stars have "*life cycles*." During most of their "lives", stars produce heavier *elements from lighter elements* starting with the *fusion* of hydrogen to *form* helium. The heaviest *elements* are formed when massive stars "die" in massive explosions.	• Connect the *life cycles* of stars to the production of *elements* through the process of nuclear *fusion*.
9-11 ES1B	The *Big Bang theory* of the origin of the universe is based on *evidence* (e.g., red shift) that all galaxies are rushing apart from one another. As space expanded and *matter* began to cool, gravitational attraction pulled clumps of *matter* together, forming the stars and galaxies, clouds of *gas* and dust, and planetary *systems* that we see today. If we were to run time backwards, the universe gets constantly smaller, shrinking to almost zero size 13.7 billion years ago.	• Cite *evidence* that supports the "Big Bang *theory*" (e.g., red shift of galaxies or 3K background radiation).

EALR 4: **Earth and Space Science**

Big Idea: **Earth Systems, Structures, and Processes (ES2)**

Core Content: ***Energy in Earth Systems***

In prior grades students learned about planet Earth as an interacting system of solids, liquids, and gases, and about the water cycle, the rock cycle, and the movement of crustal plates. In grades 9-11 students learn how the uneven heating of Earth's surface causes differences in climate in different parts of the world, and how the tilt of Earth's axis with respect to the plane of its orbit around the Sun causes seasonal variations. Students also learn about the essential biogeochemical cycles that continuously move elements such as carbon and nitrogen through Earth systems. These major ideas about energy inputs and outputs in and around the Earth help students understand Earth as a dynamic system.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 ES2A	*Global climate* differences result from the uneven heating of Earth's surface by the Sun. Seasonal *climate variations* are due to the tilt of Earth's axis with respect to the plane of Earth's nearly circular *orbit* around the Sun.	• *Explain that* Earth is warmer near the equator and cooler near the poles due to the uneven heating of Earth by the Sun. • *Explain that* it's warmer in summer and colder in winter for people in Washington State because the intensity of sunlight is greater and the days are longer in summer than in winter. Connect these seasonal changes in sunlight to the tilt of Earth's axis with respect to the plane of its *orbit* around the Sun.
9-11 ES2B	*Climate* is determined by *energy transfer* from the sun at and near Earth's surface. This *energy transfer* is influenced by dynamic processes such as cloud cover and Earth's rotation, as well as static conditions such as proximity to mountain ranges and the ocean. Human activities, such as burning of *fossil fuels*, also affect the *global climate*.	• *Explain* the factors that affect climate in different parts of Washington state.
9-11 ES2C	Earth is a *system* that contains essentially a fixed amount of each stable chemical *element* existing in different chemical forms. Each *element* on Earth moves among reservoirs in the *solid* Earth, oceans, *atmosphere*, and *organisms* as part of *biogeochemical cycle*s driven by *energy* from Earth's interior and from the Sun.	• *Describe* the different forms taken by carbon and nitrogen, and the reservoirs where they are found. • *Give examples* of carbon found on Earth (e.g., carbonate rocks such as limestone, in coal and oil, in the *atmosphere* as carbon dioxide *gas*, and in the tissues of all living *organisms*).
9-11 ES2D	The Earth does not have infinite resources; increasing human consumption impacts the natural processes that renew some resources and it depletes other resources including those that cannot be renewed.	• *Identify* renewable and nonrenewable resources in the Pacific Northwest region. • *Explain* how human use of natural resources stress natural processes and link that use to a possible long term consequence.

EALR 4: **Earth and Space Science**

Big Idea: **Earth History (ES3)**

Core Content: ***Evolution of the Earth***

In prior grades students learned about a few of the methods that have made it possible to uncover the history of our planet. In grades 9-11 students learn about the major changes in Earth systems over geologic time and some of the methods used to gather evidence of those changes. Methods include observation and measurement of sediment layers, using cores drilled from the sea bottom and from ancient glaciers, and the use of radioactive isotopes. Findings of Earth history include the existence of life as early as 3.5 billion years ago and major changes in the composition of Earth's atmosphere.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 ES3A	*Interactions* among the *solid* Earth, the oceans, the *atmosphere*, and *organisms* have resulted in the ongoing *evolution* of the Earth *system*. We can observe changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years.	• *Interpret* current rock formations of the Pacific Northwest as *evidence* of past geologic events. *Consider* which Earth processes that may have caused these rock formations (e.g., *erosion*, *deposition*, and scraping of terrain by glaciers, floods, volcanic eruptions, and *tsunami*). • Construct a possible timeline showing the development of these rock formations given the cause of the formations.
9-11 ES3B	Geologic time can be estimated by several methods (e.g., counting tree rings, observing rock sequences, using *fossils* to correlate sequences at various locations, and using the known decay rates of radioactive *isotopes* present in rocks to measure the time since the rock was formed).	• *Explain how* decay rates of radioactive materials in rock layers are used to establish the timing of geologic events. *a • Given a geologic event, *explain* multiple methods that could be used to establish the timing of that event.
9-11 ES3C	*Evidence* for one-celled forms of life—the bacteria—extends back billions of years. The appearance of life on Earth caused dramatic changes in the composition of Earth's *atmosphere*, which did not originally contain oxygen.	• *Compare* the chemical composition of the Earth's *atmosphere* before bacteria and plants evolved and after they became widespread.
9-11 ES3D	Data gathered from a variety of methods have shown that Earth has gone through a number of periods when Earth was much warmer and much colder than today.	• *Describe factors* that change climates over long periods of time and cite methods that scientists have found to gather information on ancient climates.

Mathematics Connections

*a	A1.1.A	Select and justify functions and equations to model and solve problems.
	A1.7.A	Sketch the graph for an exponential function of the form $y = ab^n$ where n is an integer, describe the effects that changes in the parameters a and b have on the graph, and answer questions that arise in situations modeled by exponential functions.
	A1.7.B	Find the approximate solutions to exponential equations.

EALR 4: Life Science

Big Idea: Structures and Functions of Living Organisms (LS1)

Core Content: *Processes Within Cells*

In prior grades students learned that all living systems are composed of cells which make up tissues, organs, and organ systems. In grades 9-11 students learn that cells have complex molecules and structures that enable them to carry out life functions such as photosynthesis and respiration and pass on their characteristics to future generations. Information for producing proteins and reproduction is coded in DNA and organized into genes in chromosomes. This elegant yet complex set of processes explains how life forms replicate themselves with slight changes that make adaptations to changing conditions possible over long periods of time. These processes that occur within living cells help students understand the commonalities among the diverse living forms that populate Earth today.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 LS1A	Carbon-containing *compounds* are the building blocks of life. *Photosynthesis* is the process that plant cells use to combine the *energy* of sunlight with *molecules* of carbon dioxide and water to produce *energy*-rich *compounds* that contain carbon (food) and release oxygen.	• *Explain how* plant cells use *photosynthesis* to produce their own food. Use the following equation to illustrate how plants rearrange *atoms* during *photosynthesis*: $6CO_2$+$6H_2O$+light *energy* —> $C_6H_{12}O_6$+$6O_2$ *a • *Explain* the importance of *photosynthesis* for both plants and animals, including humans.
9-11 LS1B	The gradual combustion of carbon-containing *compounds* within cells, called *cellular respiration*, provides the primary *energy* source of living *organisms*; the combustion of carbon by burning of *fossil fuels* provides the primary *energy* source for most of modern society.	• *Explain how* the process of *cellular respiration* is similar to the burning of *fossil fuels* (e.g., both processes involve combustion of carbon-containing *compounds* to *transform* chemical *energy* to a different *form* of *energy*). *a
9-11 LS1C	Cells contain specialized parts for determining essential *functions* such as regulation of cellular activities, *energy* capture and release, formation of proteins, waste disposal, the *transfer* of information, and movement.	• Draw, label, and *describe* the *functions* of components of essential structures within cells (e.g., *cellular membrane*, *nucleus*, *chromosome*, *chloroplast*, *mitochondrion*, *ribosome*)
9-11 LS1D	The cell is surrounded by a membrane that separates the interior of the cell from the outside world and determines which substances may enter and which may leave the cell.	• *Describe* the structure of the *cell membrane* and how the membrane regulates the flow of materials into and out of the cell.
9-11 LS1E	The *genetic information* responsible for inherited *characteristics* is encoded in the DNA *molecules* in *chromosomes*. DNA is composed of four subunits (A,T,C,G). The sequence of subunits in a *gene* specifies the amino acids needed to make a protein. Proteins express inherited traits (e.g., eye color, hair texture) and carry out most cell *function*.	• *Describe* how DNA *molecules* are long chains linking four subunits (smaller *molecules*) whose sequence encodes *genetic information*. • Illustrate the process by which *gene* sequences are copied to produce proteins.

	Content Standards	Performance Expectations
9-11 LS1F	All of the *functions* of the cell are based on *chemical reactions.* Food *molecules* are broken down to provide the *energy* and the chemical constituents needed to synthesize other *molecules*. Breakdown and synthesis are made possible by proteins called *enzymes.* Some of these *enzymes* enable the cell to store *energy* in special chemicals, such as ATP, that are needed to drive the many other *chemical reactions* in a cell.	• *Explain how* cells break down food *molecules* and use the constituents to synthesize proteins, sugars, fats, DNA and many other *molecules* that cells require. • *Describe* the role that *enzymes* play in the breakdown of food *molecules* and synthesis of the many different *molecules* needed for cell structure and *function.* • *Explain how* cells extract and store *energy* from food *molecules.*
9-11 LS1G	Cells use the DNA that forms their *genes* to encode *enzymes* and other proteins that allow a cell to grow and divide to produce more cells, and to respond to the *environment*.	• *Explain that* regulation of cell *functions* can occur by changing the activity of proteins within cells and/or by changing whether and how often particular *genes* are expressed.
9-11 LS1H	*Genes* are carried on *chromosomes.* Animal cells contain two copies of each *chromosome* with *genetic information* that regulate body structure and *functions*. Most cells divide by a process called *mitosis,* in which the *genetic information* is copied so that each new cell contains exact copies of the original *chromosomes*.	• *Describe* and *model* the process of *mitosis,* in which one cell divides, producing two cells, each with copies of both *chromosomes* from each pair in the original cell.
9-11 LS1I	Egg and sperm cells are formed by a process called *meiosis* in which each resulting cell contains only one representative *chromosome* from each pair found in the original cell. *Recombination* of *genetic information* during *meiosis* scrambles the *genetic information,* allowing for new *genetic* combinations and *characteristics* in the offspring. *Fertilization* restores the original number of *chromosome* pairs and reshuffles the *genetic information*, allowing for *variation* among offspring.	• *Describe* and *model* the process of *meiosis* in which egg and sperm cells are formed with only one set of *chromosomes* from each parent. • *Model* and *explain* the process of *genetic recombination* that may occur during *meiosis* and how this then results in differing *characteristics* in offspring. • *Describe* the process of *fertilization* that restores the original *chromosome* number while reshuffling the *genetic information,* allowing for *variation* among offspring. • *Predict* the outcome of specific *genetic* crosses involving two *characteristics* *a,*b

Mathematics Connections

*a	A1.3.B	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
*b	A1.6.B	Make valid inferences and draw conclusions based on data.

EALR 4: **Life Science**

Big Idea: **Ecosystems (LS2)**

Core Content: ***Maintenance and Stability of Populations***

In prior grades students learned to apply key concepts about ecosystems to understand the interactions among organisms and the nonliving environment. In grades 9-11 students learn about the factors that foster or limit growth of populations within ecosystems and that help to maintain the health of the ecosystem overall. Organisms participate in the cycles of matter and flow of energy to survive and reproduce. Given abundant resources, populations can increase at rapid rates. But living and nonliving factors limit growth, resulting in ecosystems that can remain stable for long periods of time. Understanding the factors that affect populations is important for many societal issues, from decisions about protecting endangered species to questions about how to meet the resource needs of civilization while maintaining the health and sustainability of Earth's ecosystems.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 LS2A	*Matter* cycles and *energy* flows through living and nonliving components in *ecosystems*. The *transfer* of matter and *energy* is important for maintaining the health and sustainability of an *ecosystem*.	• *Explain how* plants and animals cycle carbon and nitrogen within an *ecosystem*. • *Explain how* matter cycles and *energy* flows in ecosystems, resulting in the formation of differing chemical compounds and *heat*.
9-11 LS2B	Living *organisms* have the capacity to produce very large *populations*. *Population density* is the number of individuals of a particular *population* living in a given amount of space.	• *Evaluate* the conditions necessary for rapid *population growth* (e.g., given adequate living and nonliving resources and no disease or predators, *populations* of an *organism* increase at rapid rates). • Given *ecosystem* data, calculate the *population density* of an *organism*.*a
9-11 LS2C	*Population growth* is limited by the availability of matter and *energy* found in resources, the size of the *environment*, and the presence of competing and/or predatory *organisms*.	• *Explain factors*, including matter and *energy*, in the *environment* that limit the growth of plant and animal *populations* in natural *ecosystems*.*a
9-11 LS2D	Scientists represent *ecosystems* in the *natural world* using mathematical *models*.	• Draw a *systems* diagram to illustrate and *explain* why introduced (nonnative) *species* often do poorly and have a tendency to die out, as well as why they sometimes do very well and force out native *species*. *a, *b
9-11 LS2E	Interrelationships of *organisms* may *generate ecosystems* that are stable for hundreds or thousands of years. *Biodiversity* refers to the different kinds of *organisms* in specific *ecosystems* or on the planet as a whole.	• *Compare* the *biodiversity* of *organisms* in different types of *ecosystems* (e.g., rain forest, grassland, desert) noting the interdependencies and interrelationships among the *organisms* in these different *ecosystems*.

	Content Standards	Performance Expectations
9-11 LS2F	The *concept* of *sustainable development* supports adoption of policies that enable people to obtain the resources they need today without limiting the ability of future *generations* to meet their own needs. Sustainable processes include substituting renewable for nonrenewable resources, recycling, and using fewer resources.	• *Explain how* scientific *concepts* and findings relate to a resource issue currently under discussion in the state of Washington (e.g., removal of dams to facilitate salmon spawning in rivers; construction of *wind* farms).* a,*b,*c. • *Explain how* the *concept* of *sustainable development* may be applied to a current resource issue in the state of Washington.*a,*b,*c.

Mathematics Connections

*a	A1.8.A	Analyze a problem situation and represent it mathematically.
	7.2.E	Represent proportional relationships using graphs, tables, and equations, and make connections among the representations.
	A1.3.B	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
	A1.2.B	Recognize the multiple uses of variables, determine all possible values of variables that satisfy prescribed conditions, and evaluate algebraic expressions that involve variables.
*b	A1.6.B	Make valid inferences and draw conclusions based on data.
	A1.7.D	Solve an equation involving several variables by expressing one variable in terms of the others.
*c	A1.3.B	Represent a function with a symbolic expression, as a graph, in a table, and using words, and make connections among these representations.
	A1.6.B	Make valid inferences and draw conclusions based on data.

EALR 4: **Life Science**

Big Idea: **Biological Evolution (LS3)**

Core Content: ***Mechanisms of Evolution***

In prior grades students learned how the traits of organisms are passed on through the transfer of genetic information during reproduction. In grades 9-11 students learn about the factors that underlie biological evolution: variability of offspring, population growth, a finite supply of resources, and natural selection. Both the fossil record and analyses of DNA have made it possible to better understand the causes of variability and to determine how the many species alive today are related. Evolution is the major framework that explains the amazing diversity of life on our planet and guides the work of the life sciences.

	Content Standards	**Performance Expectations**
	Students know that:	*Students are expected to:*
9-11 LS3A	Biological *evolution* is due to: (1) *genetic variability* of offspring due to *mutations* and *genetic recombination*, (2) the potential for a *species* to increase its numbers, (3) a finite supply of resources, and (4) *natural selection* by the *environment* for those offspring better able to survive and produce offspring.	• *Explain* biological *evolution* as the consequence of the *interactions* of four *factors*: *population growth*, inherited variability of offspring, a finite supply of resources, and *natural selection* by the *environment* of offspring better able to survive and reproduce. • *Predict* the *effect* on a *species* if one of these *factors* should change.*a
9-11 LS3B	Random changes in the *genetic* makeup of cells and *organisms* (*mutations*) can cause changes in their physical *characteristics* or behaviors. If the *genetic mutations* occur in eggs or sperm cells, the changes will be inherited by offspring. While many of these changes will be harmful, a small minority may allow the offspring to better survive and reproduce.	• *Describe* the molecular process by which *organisms* pass on physical and behavioral traits to offspring, as well as the *environmental* and *genetic factors* that cause minor differences (*variations*) in offspring or occasional “mistakes” in the copying of *genetic* material that can be inherited by future *generations* (*mutations*). • *Explain how* a *genetic mutation* may or may not allow a *species* to survive and reproduce in a given *environment*.
9-11 LS3C	The great *diversity* of *organisms* is the result of more than 3.5 billion years of *evolution* that has filled available *ecosystem niches* on Earth with life *forms*.	• *Explain how* the millions of different *species* alive today are related by descent from a *common ancestor*. • *Explain that genes* in *organisms* that are very different (e.g., yeast, flies, and mammals) can be very similar because these *organisms* all share a *common ancestor*.
9-11 LS3D	The *fossil* record and anatomical and molecular similarities observed among diverse *species* of living *organisms* provide *evidence* of biological *evolution*.	• Using the *fossil* record and anatomical and/or molecular (DNA) similarities as *evidence*, formulate a *logical argument* for biological *evolution* as an explanation for the development of a representative *species* (e.g., birds, horses, elephants, whales).

	Content Standards	Performance Expectations
9-11 LS3E	*Biological classifications* are based on how *organisms* are related, reflecting their evolutionary history. Scientists *infer relationships* from physiological traits, *genetic information*, and the ability of two *organisms* to produce fertile offspring.	• *Classify organisms*, using similarities and differences in physical and functional *characteristics*. • *Explain* similarities and differences among closely related *organisms* in terms of biological *evolution* (e.g., "Darwin's finches" had different beaks due to food sources on the islands where they evolved).

Mathematics Connections

*a	8.3.F	Determine probabilities for mutually exclusive, dependent, and independent events for small sample sizes.

Acknowledgments

These *Washington State K-12 Science Standards* have been developed by Washington educators, science faculty, scientists, and citizens with support from the Office of the Superintendent of Public Instruction in collaboration with the Washington State Board of Education. Additional assistance was provided by national consultant teams led by Dr. David Heil, who reviewed the previous science standards and made recommendations, and by Dr. Cary Sneider, who facilitated the development process. Individuals who have played key roles in developing this document are listed below.

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Appendix A. Big Ideas of Science

The *Washington State K-12 Science Standards* consists of four Essential Academic Learning Requirements (EALRs). The first three are EALR 1 Systems, EALR 2 Inquiry, and EALR 3 Application. Each of these is a Big Idea consisting of concepts and abilities that cut across all domains of science. EALR 4 includes nine additional Big Ideas within the domains of Life, Physical, and Earth and Space Science. Appendix A summarizes all twelve Big Ideas, illustrating how they change over the grade bands.

Crosscutting Concepts and Abilities

Systems. The idea of systems analysis arose first in the life sciences, where the reductionist methods of physics failed to account for the many interactions among organisms and their environments. Later, Earth and Space Science adopted a view of our planet as four interacting systems—the rocky geosphere, the watery hydrosphere, the atmosphere, and the biosphere. Systems thinking also has many applications in physics. In addition to its use within domains, systems thinking provides a bridge between science domains. In elementary school students learn to think systematically about how the parts of objects, plants, and animals are connected and work together, noting that properties of a whole object or organism are different from the properties of its parts and that if one or more parts are removed, the whole system may fail. In upper elementary school, students learn that systems contain smaller (sub-) systems, and they are also parts of larger systems. In middle school the focus is on more complex ideas including systems boundaries, open and closed systems, and the flow of matter and energy through systems. In high school students learn to use the concept of feedback in developing models of systems and recognize that new and unpredictable properties may emerge in complex systems. Students can apply this more sophisticated understanding to analyzing real-world societal issues, which in turn helps them further develop their "systems thinking" abilities. The aim of this sequence of standards is for every student to be ready and able to use systems thinking whenever they encounter a complex problem with numerous factors and interconnections.

Inquiry. The bedrock of science is an understanding of the nature of science, as well as the ability to investigate the natural world. As used in this document, the term "inquiry" is not a method of teaching, but rather content that students are expected to learn. Inquiry includes an understanding of the nature of science as well as the ability to plan and conduct scientific *investigation*s and to recognize the critical importance of collaboration and intellectual honesty. In elementary school children are naturally curious about nearly everything—butterflies, clouds, and why the Moon seems to follow them at night. The essence of this standard is to channel this natural curiosity about the world so that students become better observers and logical thinkers. As children mature through the elementary grades they learn that different types of questions require different types of *investigation*s, and that answering questions often involves collecting and analyzing evidence. In middle school students learn to revise questions so they can be answered scientifically, design an appropriate *investigation* to answer the question, and carry out the study. Students are able to work well in collaborative teams and can communicate the procedures and results of their *investigation*s. High school students extend and refine their understanding of the nature of inquiry and are more competent in using mathematical tools and information technology, including computers, when available. They are also able to make closer connections between their *investigation*s and the science domains (reflecting increased knowledge), and to improve their abilities to communicate, collaborate, and participate in a community of learners.

Application. Knowledge of science, in and of itself, is not sufficient to prepare today's students for the world of tomorrow. It is important that our children learn how science and technology function together to shape our world and to become culturally sensitive and ethical problem solvers. Developing these capabilities begins in the earliest grades, when students learn to distinguish between natural materials and designed materials. Elementary students learn that tools and materials can be used to solve problems and that many problems have more than one solution. Through the elementary years students develop the ability to design a solution to a simple problem and to select the appropriate tools and materials to make something of their own design. By the time they leave elementary school, students should understand that people of many different backgrounds find satisfying work applying science and technology to real-world problems. Abilities in technological design continue to develop in middle school as students learn that teamwork is essential in solving problems and that scientists and engineers often work side by side, applying insights from nature along with mathematics and creativity. They also learn design principles, such as the use of models to identify weak points in a design, and the full engineering design process. As high school students turn their attention to local, regional, and global issues, they transfer their learning to more challenging and far-reaching problems that require both a scientific and technological lens. Students also develop a long-range perspective, taking into account possible unanticipated side effects of new technologies. Through more advanced courses in high school students realize that science and technology are not always objective, but rather that they interact with societal perspectives and concerns, and that science and technology are limited—they cannot solve all human problems or answer all questions.

Physical Science

Force and Motion. The Big Idea of Force and Motion that culminates in Newton's Laws starts in grades K-1 with the concepts of force and motion and various kinds of forces in our environment, including those that act by contact and those that act at a distance (magnetism). In upper elementary school students measure the quantities of force, time, and distance, and *compare* the speed of two objects. In middle school students calculate the average speed of objects and tabulate and graph the results. They also develop a qualitative understanding of inertia. In grades 9 through 11 students acquire a deeper understanding of the relationships among force, mass, and acceleration ($F=ma$) and learn that forces between two bodies are equal and opposite. They also learn that the force of gravity between two objects is proportional to their masses and inversely proportional to the square of the distance between them. Students also learn about electrical and magnetic forces and how these two forces combine in the electromagnetic force, which makes possible electric generators, motors, and other devices.

Matter: Properties and Change. Although the atomic-molecular model of matter is not introduced until middle school, students start preparing for it in the earliest grades by learning about the properties of matter and that the properties of an object depend in part on the type of material of which it is composed. In upper elementary school students learn about the different states of matter: solid, liquid, and gas. In middle school students learn that the observable properties of a substance are due to the kinds of atoms that make up the substance and how those atoms interact with other atoms. The compounds that are produced by chemical reactions often have properties that are different from the reactants. Students also learn about conservation of mass in chemical reactions. At the high school level students learn more about the structure of atoms and molecules, the various substances that they form, and how to use chemical equations to determine how atoms are rearranged during chemical reactions. They also learn about the components of the nucleus, the process of nuclear decay and formation of isotopes, and fission and fusion reactions.

Energy: Transfer, Transformation, and Conservation. Although it is difficult to define, the concept of energy is very useful in virtually all fields of science and engineering. Starting in elementary school students learn that there are different forms of energy. In upper elementary school they learn that energy can be transferred from one place to another and become more familiar with the various forms of energy. Energy topics for middle school include the idea that heat (thermal energy) always moves from a warmer place to a cooler place through solids (by conduction) and through liquids and gases (mostly by convection, or mechanical mixing). Light energy interacts with matter and our eyes, allowing us to see things. Electrical energy from a generator or battery can be transformed to a different kind of energy, providing a convenient way for us to use energy where and when we need it. Focus in high school is on the Law of Conservation of Energy—that during transfers and transformations, the total amount of energy in the universe is constant. Other high school concepts include transformation between gravitational potential and kinetic energy, the properties of waves, and the electromagnetic spectrum.

Earth and Space Science

Earth in the Universe. Observations from Earth and near-Earth orbit have revealed features of Solar System bodies, more than 300 planetary systems around other stars, the shape and dynamics of our home galaxy, and the structure and evolution of the universe as a whole. Sharing these discoveries with students and helping them develop a mental model of Earth in the Universe is an essential component of the modern worldview. In the first years of school students learn that the Sun and Moon exhibit patterns of movement if observed carefully over time. Focus in upper elementary school is on the implications of the spherical Earth concept, including its daily rotation and yearly orbit around the Sun. During middle school students build a richer mental model of Earth in space, starting with Moon phases and eclipses and moving on to other bodies in the Solar System, the Solar System's place within the Milky Way galaxy, and hundreds of billions of other galaxies. High school students learn about the life cycles of stars, the formation of elements, and the scientific theory for the beginning of time, space, and energy—the Big Bang.

Earth Systems, Structures, and Processes. There are many different Earth sciences, including geology, oceanography, climatology, and meteorology, to name a few. Two essential concepts that unify these fields are "matter," including the movement of matter through Earth systems, and the concept of "energy," including energy from the Sun and from Earth's interior. Starting in elementary school children learn about Earth materials and how they are modified for human uses. The essential role that water plays in many Earth systems is the focus for grades 2 and 3, including where it is found, solid and liquid forms, and its role in weather. In grades 4 and 5 students learn that water occurs naturally in all three states and plays an essential role in shaping landforms and creating soils. Water is essential for life, but it can also be destructive when too much is deposited too rapidly. Earth as a dynamic planet is the focus for middle school. Students learn that solar energy powers the water cycle and drives the weather system and ocean currents. Energy from deep within the planet drives the rock cycle and moves huge plates on Earth's surface, causing earthquakes, volcanoes, and mountain building. In high school, students learn about Earth processes on a global scale, including major weather systems and the essential biogeochemical cycles that continuously move elements such as carbon and nitrogen through Earth systems.

Earth History. The remarkable discoveries about the history of our planet made by Earth scientists during the 20^{th} century illustrate the power of evidence and inference. In upper elementary school students learn that fossils not only provide evidence of organisms that lived long ago; they also make it possible to infer past climates. In middle school, students learn about the fundamental insights that led to uncovering Earth's ancient history, such as sedimentation and rock formation, and the interpretation of the evidence in various geologic formations. That history includes both slow, gradual changes such as mountain building and rapid catastrophic events, such as impacts from comets and asteroids. Students also learn about the first one-celled life forms responsible for enriching our atmosphere with oxygen. High school students learn about the use of various methods, including radioactive isotopes, to determine the age of rock formations and of the Earth itself. Evidence uncovered by these methods reveals a planet that had no oxygen in its atmosphere until the evolution of life about 3.5 billion years ago, and huge shifts in climate including the series of ice ages that began just a few million years ago.

Life Science

Structures and Functions of Living Organisms. Living organisms are complex systems that gather energy and material from the environment to carry on life processes. In the earliest grades students learn that plants and animals have body parts with different functions to meet their needs. In grades 2 and 3 students *compare* the life cycles of various plants and animals, and in grades 4 and 5 they learn about the various structures and behaviors that enable plants and animals to respond to their needs. Focus in middle school is on cells—the fundamental unit of life. Cells combine to make tissues, which make up organs that function together in organ systems that cumulatively form the whole organism. At each level of organization, structures enable functions required by the organism. The complex internal structure and functions of cells are the focus in high school. Information for producing proteins and reproduction is coded in DNA molecules, which are organized into genes and chromosomes. This elegant yet complex set of processes answers fundamental questions about how life functions and how life forms are able to replicate themselves with slight changes that make it possible for species to adapt to changing conditions.

Ecosystems. An *ecosystem* includes all of the plant and animal populations and nonliving resources in a given area. In grades 2 and 3, students learn that every organism obtains materials and energy from the environment to meet its needs. In grades 4 and 5, students learn that each organism has a different relationship to every other organism in its ecosystem. Plants have a special role as producers that make their own food and provide food for all other organisms. A food web shows how energy makes its way from organism to organism through the ecosystem. Middle school students learn that different ecosystems have similar patterns in the ways that matter and energy flow through them. High school students focus on the flow of energy through ecosystems and the factors that maintain an ecosystem's long-term stability, as well as factors that can destabilize an ecosystem, such as the introduction of new species. Students consider the effects of harvesting resources in ecosystems and the concept of sustainable development.

Biological Evolution. Evolution is the essential framework for understanding change in organisms over time. In the earliest grades children learn about the amazing diversity of Earth's organisms and their relatedness to one another. In grades 2 and 3 students observe that offspring of plants and animals closely resemble their parents, but offspring are never *exactly* the same as their parents. In grades 4 and 5 students learn that some characteristics are acquired and others are inherited. In middle school they learn that the processes of inheritance, mutation, and natural selection account for the diversity of species that exist today. High school students learn about the major factors that drive evolution and the molecular basis for inheritance and mutation. Students learn more about the processes of evolution by the classification of organisms and by tracing the evolution of a single species.

Appendix B. Glossary

Accelerate: Change in velocity over time. The rate at which something speeds up or slows down.

Adaptation: Any change in the structure or functioning of an organism that is favored by natural selection and makes the organism better suited to its environment.

Air: The mixture of gases in the Earth's atmosphere is commonly known as air. Earth's atmosphere is a layer of gases surrounding our planet that is retained by Earth's gravity. Dry air contains roughly 78% nitrogen, 21% oxygen, and 1% trace gases, primarily water vapor.

Allele: One member of a pair or series of different forms of a gene.

Analyze: To separate into separate parts or basic principles to determine the nature of the whole.

Anatomical feature: A structure found in a living thing (e.g., heart, lung, liver, backbone).

Apply: The skill of selecting and using information in new situations or problems.

Aqueous solution: A solution in which the solvent is water.

Asexual reproduction: Involves the growth of a new organism by fission of cell nuclei. Asexual reproduction usually involves one parent and leads to offspring that are genetically identical to the parent and to one another.

Asteroid: A small rocky body orbiting the Sun, sometimes called minor planet or planetoid.

Atmosphere: A layer of gases that may surround the Earth and other material bodies of suffient mass.

Atom: A basic unit of matter consisting of a dense central nucleus surrounded by a cloud of negatively charged electrons.

Atomic mass number: The total number of protons and neutrons in the nucleus of a single atom.

Atomic number: The number of protons in the nucleus of an atom.

Average acceleration: Change in velocity and/or direction with respect to time. Acceleration is a vector quantity, so both velocity and direction are required to define it.

Average speed: The measure of distance that an object travels in a given time interval.

Average velocity: Change in position and/or direction with respect to time. Velocity is a vector quantity, so both speed and direction are required to define it.

Biodiversity: The different kinds of organisms in a specific ecosystem or on the planet as a whole.

Biogeochemical cycle: A circuit or pathway by which a chemical element moves through both living and non-living components of an ecosystem, including the Earth as a whole.

Biological classification: A method by which biologists group and categorize species of organisms. Biological classification is a form of scientific taxonomy.

Boiling point: The temperature at which a liquid changes state and becomes a gas. The boiling point changes as pressure changes.

Carbon cycle: The biogeochemical cycle that describes the transformations of carbon and carbon-containing compounds in nature.

Cellular membrane: The biological membrane separating the interior of a cell from the outside environment. It is a semipermeable lip bilayer found in all cells.

Cellular respiration: The process by which molecules are converted into useable energy in cells.

Challenges: Problems that can be solved using science concepts and principles, inquiry, and the technological design process.

Characteristic: A distinguishable trait, quality, or property.

Chemical change: A chemical change occurs whenever compounds are formed or decomposed. During this type of reaction, there is a rearrangement of atoms that makes or breaks chemical bonds.

Chemical properties: Any of a material's properties, such as color, pH, or ability to react with other chemicals, that becomes evident during a chemical reaction.

Chemical reaction: A process that results in the conversion of chemical substances (reactants) to other substances (products). Products generally have different chemical properties from the reactants.

Chloroplast: An organelle found only in plants and photosynthetic protists; contains chlorophyll, which absorbs the light energy used to drive photosynthesis.

Chromosome: An organized structure of DNA and supporting regulatory proteins found in cells. Chromosomes contain many genes.

Claim: A proposition based on evidence and logical argument.

Classify: To arrange in some sort of order by categories or groupings.

Climate: Encompasses the temperatures, humidity, atmospheric pressure, winds, rainfall, atmospheric particle count, and numerous other meteorological elements in a given region over long periods of time.

Closed system: A system in which matter may circulate, but may not enter or leave.

Comet: A small Solar System body that orbits the Sun and, when close enough to the Sun, exhibits a visible coma (atmosphere) and/or a tail made of gas and/or dust.

Common ancestors: A group of organisms is said to have common descent if they have a common ancestor. In modern biology, it is generally accepted that all living organisms on Earth are descended from a common ancestor or ancestral gene pool.

Common: Refers to materials and processes that most students have experienced.

Communicate: Participate in the discourse of science. Communication includes but is not limited to discussions, journaling, and sharing the results of investigations effectively and clearly in both written and oral forms.

Compare: To examine two or more objects or events to establish similarities and differences.

Comparison: An examination of two or more objects or events to establish similarities and differences.

Compound: A substance consisting of two or more different elements chemically bonded together in a fixed proportion by mass that can be split up into simpler substances through a chemical reaction.

Concept: An abstract, universal idea of phenomena or relationships among phenomena.

Conclusion: A statement of the findings of an investigative process that is supported by investigative evidence (data) and links to the current body of scientific knowledge.

Condensation: The change of the physical state of matter from a gas to a liquid.

Conduction: The transfer of heat energy through matter by kinetic energy from particle to particle with no net displacement of the particles.

Confidence: Assurance that the conclusions of an investigation are reliable and valid.

Conservation of Energy: A physical law stating that the total amount of energy in an isolated system remains constant. Also stated as: energy cannot be created or destroyed—only changed from one form to another.

Conservation of Mass: A physical law stating that the total amount of mass in a closed system remains constant. Also stated as: mass can be neither created nor destroyed during a chemical reaction—only rearranged.

Conservation: To preserve. In physics, the Conservation Laws specify quantities that are preserved during transformations.

Consider: Sustained purposeful concentration and attention to details in an attempt to reach the truth or arrive at a decision about the validity of evidence or a claim.

Constellation: A group of stars that appear to form a visible figure or picture as viewed by people in a particular culture.

Constraint: The limitations imposed on possible solutions to problems or challenges. Constraints are often expressed in terms of available money, materials, or time.

Consumer: An organism that gets its chemical energy for growth and development from other organisms. Animals in a food web are consumers that obtain food energy by eating other animals or plants.

Contrast: To examine two or more objects or events to establish differences.

Control: A standard condition that other conditions can be compared to in a scientific experiment.

Controlled experiment: A laboratory investigation in which the values of all variables are kept the same except for one that is changed from trial to trial (manipulated or independent variable) and one that is measured (responding or dependent variable).

Controlled variable: The conditions that are kept the same from trial to trial in a laboratory investigation.

Convection: The physical movement of molecules within fluids (e.g., liquids, and gases). Convection is one of the major modes of heat transfer and mass transfer.

Core of the Earth: Earth's core is most likely a solid sphere about 1,220 km in radius. It is believed to consist of an iron-nickel alloy, and is likely surrounded by a liquid outer core, extending to about 3,400 km from the center of our planet.

Core: Used literally, core refers to whatever is in the center of an object, as the core of an apple, or Earth's core. Used metaphorically, core refers to what is most important, as in "core content."

Correlation: A known relationship between two variables in which it is not possible to infer whether or not a change in one variable caused a change in the other variable.

Covalent bond: A form of chemical bond characterized by sharing of pairs of electrons between atoms, or between atoms and other covalent bonds.

Criteria: A standard on which to judge success (plural form: criteria).

Critique: A critical review of a specific topic, process, or investigation.

Crust: Earth's outermost shell that is composed of a variety of igneous, metamorphic, and sedimentary rocks. Earth's crust includes the oceanic crust, about 7-10 km thick, and the continental crust, about 35-40 km thick.

Crustal plate: The outermost part of the Earth's interior mantle contains the lithosphere which is divided into eight major tectonic or crustal plates that float on the asthenosphere and move in relation to one another.

Culture: Refers to patterns of human activity and the symbolic structures that give such activities significance and importance within a society.

Decompose: To break down tissue of a formerly living organism into simpler forms of matter.

Decomposers: Organisms that consume the remains of dead organisms and, in doing so, break down the tissues into simpler forms of matter that can be used as nutrients for other living organisms.

Dehydration synthesis: A chemical reaction in which two molecules or functional groups combine to form one single molecule, with the accompanying loss of a small molecule. When this small molecule is water, it is known as a dehydration synthesis.

Density: Mass per unit volume.

Dependent variable: The factor of a system being investigated that changes in response to the manipulated (independent) variable and is measured.

Deposition of sediments: Refers to the geologic process following erosion, in which particles of sand or soil are no longer transported from their source by wind or water and are added to a new landform.

Describe: The skill of developing a detailed picture, image, or characterization using diagrams and/or words, written or oral.

Design: (Noun): Either the final plan (proposal, drawing, or model) or the result of implementing that plan in the form of the final product of a design process.

Design: (Verb): The process of originating and developing a plan for a product, structure, system, or component to meet a human need or want.

Designed world: Systems or subsystems of the natural world built entirely or in part by people. Also called the constructed world.

Discriminate: The skill of distinguishing accurately between and among pieces of evidence.

Diversity: Wide variety. Species diversity refers to the abundance of different species within an ecosystem.

DNA: Large molecules inside the nucleus of living cells that carry genetic information. The scientific name for DNA is deoxyribonucleic acid.

Dwarf planet: A body gravitationally bound to the Sun with sufficient mass to be approximately spherical in shape, but not enough mass to have pulled in debris from the neighborhood of their orbit. Plutoids are dwarf planets that orbit further from the Sun than Neptune.

e.g.: Abbreviation meaning “for example” or “for instance.” Refers to examples given in Performance Expectations.

Eclipse: An astronomical event that occurs when one celestial object moves into the shadow of another. The term eclipse is most often used to describe either a solar eclipse, when the Moon's shadow crosses Earth's surface, or a lunar eclipse, when the Moon moves into the shadow of Earth.

Ecosystem: A natural unit consisting of all plants, animals, and microorganisms (biotic factors) in an area functioning together with all of the nonliving physical (abiotic) factors of the environment.

Effect: The result or consequence of an action, influence, or causal agent.

Electric circuit: An interconnection of electrical elements such as resistors, inductors, capacitors, transmission lines, voltage sources, current sources, and switches that has a closed loop, giving a return path for the current.

Electromagnetic force: One of the four known fundamental forces in the universe; includes the forces between charged particles and between molecules and ions.

Electromagnetic spectrum: The array of electromagnetic waves, from the shortest and most energetic gamma rays to the longest radio waves. The visible light spectrum is a small part of the middle range of the electromagnetic spectrum.

Electromagnetic waves: A self-propagating wave that includes visible light, radio waves, microwaves, infrared radiation, ultraviolet radiation, X-rays, and gamma rays. EM radiation is composed of an oscillating electric and magnetic field that moves through empty space or transparent matter.

Electron: An elementary subatomic particle that carries a negative electrical charge.

Element: A pure chemical substance composed of all atoms that have the same number of protons.

Empirical: Based on actual measurements, observations, or experience rather than on theory.

Energy transfer: The movement of energy from one location to another.

Energy transformation: Change of energy from one form to another.

Energy: The amount of work that can be done by a force.

Environment: Natural surroundings, including living and nonliving components. May also refer to a region or to all natural systems on planet Earth.

Enzyme: Biological molecules that catalyze (increase the rates of) chemical reactions. Almost all enzymes are proteins.

Equilibrium: The condition of a system in which competing influences are balanced.

Erosion: The carrying away or displacement of solids (sediment, soil, rock, and other particles), usually by wind, water, or ice by down-slope movement in response to gravity or by living organisms.

Error: Mistakes of perception, measurement, or process during an investigation; an incorrect result or discrepancy.

Established: A proven or demonstrated inference or theory.

Evaluate: To make judgments or appraisals based on collected data.

Evaporation: The change in state of a substance from liquid to gas.

Evidence: Observations, measurements, or data collected through established and recognized scientific processes.

Evolution: A series of gradual or rapid changes, some regular, some random, that account for the present form and function of phenomena both living and nonliving.

Examine: To use a scientific method of observation to explore, test, or inquire about a theory, hypothesis, inference, or conclusion.

Experiment: An investigation under which the conditions for a phenomenon to occur are arranged beforehand by the investigator.

Explain how: The skill of making a process plain and comprehensible, possibly including supporting details with an example.

Explain that: The skill of making plain and comprehensible a theory, hypothesis, inference, or conclusion, possibly including supporting details with an example.

Explain: To apply scientific ideas to describe the cause of a phenomenon or relationship, and/or to render a complex idea plan.

Extinction: The death of all members of a species of plant or animal. The moment of extinction is generally considered to be the death of the last individual of that species, although the capacity to breed and recover may have been lost before this point.

Factor: Agent or condition that could cause a change.

Fault: In geology, a fault or fault line is a rock fracture that shows evidence of relative Earth movement. Some faults may extend hundreds or even thousands of kilometers.

Feedback: The process by which the output of a system is used to make changes in the operation of the system. Feedback can be negative, which reduces the disturbance to a system, or positive, which tends to increase the disturbance to a system.

Fertilization: The union of an egg nucleus and a sperm nucleus.

Field studies: The scientific study of free-living plants or animals in which the subjects are observed in their natural habitat without changing, harming, or materially altering the setting or subjects of the investigation.

Fission: Nuclear fission is the process by which the nucleus of a large atom is split into two smaller atomic nuclei.

Food web: The complex eating relationships among species within an ecosystem. In a diagram of a food web organisms are connected to the organisms they consume by arrows representing the direction of energy transfer.

Force: A push or pull. In physics, it is whatever can cause an object with mass to accelerate. Force has both magnitude and direction, making it a vector quantity.

Form: The shape, appearance, or configuration of an object or organism.

Fossil Fuel: A substance that can be burned for heat energy, such as coal, oil, or natural gas, formed from the decayed remains of prehistoric animals and plants.

Fossil: The preserved remains or traces of animals, plants, and other organisms from the remote past.

Frictional force: The force resisting the relative motion of two surfaces in contact **or** a surface in contact with a fluid (e.g., air on an aircraft or water in a pipe). Also referred to as "friction."

Function: The normal and specific contribution of a bodily or cellular part to the economy of a living organism.

Fusion: Combining two or more distinct things. Nuclear fusion refers to the process by which multiple nuclei join together to form a heavier nucleus.

Gas: A state of matter consisting of a collection of particles (molecules, atoms, ions, electrons, etc.) without a definite shape or volume that are in more or less random motion.

Gene: A segment of inheritance information that, taken as a whole, specifies a trait. In common language the term "gene" sometimes refers to the scientific concept of an allele.

Generate: To produce.

Generation: A generation is defined as "the average interval of time between the birth of parents and the birth of their offspring."

Genetic information: A set of instructions coded in DNA molecules that specifies the traits of an organism.

Genetic recombination: The regrouping of genes in an offspring caused by the crossing over of chromosomes during meiosis.

Genetic variation: A measure of the tendency of individual genotypes in a population to vary from one to another.

Genetic: Inherited or affected by genes.

Global climate: The average temperature, humidity, rainfall, and other meteorological measures of Earth as a whole over a long period of time (usually taken to be about 30 years).

Gravitational potential energy: Energy associated with gravitational force. Factors that affect an object's gravitational potential energy are its height relative to some reference point, its mass, and the strength of the gravitational field.

Gravity: The force by which any two masses are attracted to one another. The term is sometimes used to refer to Earth's gravity.

Habitat: An ecological or environmental area that is inhabited by a particular species. It is the natural environment in which an organism lives or the physical environment that surrounds (influences and is used by) a species population.

Heat: A form of kinetic energy produced by the motion of atoms and molecules. Also known as thermal energy, heat may be transferred from one body or system to another due to a difference in temperature.

Heredity: The passing of traits to offspring. This is the process by which an offspring cell or organism acquires the characteristics of its parent cell or organism.

Human-made or man-made: The designed or modified environment (also called the built environment) created by people to meet their needs. The term also describes the interdisciplinary field concerned with the design, management, and use of the human-made environment.

Human problems: Difficulties for individuals or populations that call for a solution.

Hypothesis: A testable explanation for a specific problem or question based on what has already been learned. A hypothesis may be stated in an “if-then” format that predicts a causal relationship or correlation between two variables.

Idea: A general perception, thought, or concept.

Igneous rock: Rocks formed when molten magma cools. Igneous rocks are divided into two main categories: Plutonic rocks result when magma cools and crystallizes slowly within the Earth's crust (e.g., granite), while volcanic rocks result from magma reaching the surface either as lava or fragments that are ejected into the air (e.g., pumice and basalt).
In biology: the central structure in a living cell enclosed in a membrane that includes most of the genetic information in the cell.

Independent (manipulated) variable: The factor of a system being investigated that is changed to determine that factor’s relationship to the dependent (responding) variable.

Index fossil: Fossil that is used to determine relative age of layer of sedimentary rock.

Infer: To arrive at a decision or logical conclusion by reasoning from evidence.

Inference: A logical conclusion based on evidence.

Information explosion: The rapid expansion of knowledge of the natural world, in part brought about by new knowledge and new technologies into the scientific, technological, and communication enterprises.

Information technology: The branch of technology devoted to the acquisition, processing, storage, retrieval, and application of data. The term also applies to the hardware (e.g., computers and cell phones) and software developed to utilize data.

Input: The addition of matter, energy, or information to a system.

Inquiry: The diverse ways in which people study the natural world and propose explanations based on evidence derived from their work.

Insulator: A material that is a poor conductor of energy such as electricity or heat.

Integrity: A state of honesty; freedom from corrupting influence, motive, or bias in the collection and interpretation of data and observations.

Interactions: The mutual influences among variables in a system or between subsystems, which may be correlational or causal.

Interpret: To present an explanation of an event or process.

Interpretation: Inferences drawn from data collected during a scientific investigation.

Intrinsic: A property of something or action which is essential and specific to that thing or action, and which is wholly independent of any other object, action, or consequence.

Investigate: To plan and conduct an organized scientific study to answer a question.

Investigation: A multifaceted, organized scientific study of the natural world. Investigations may include such activities as making systematic observations; asking questions; gathering information through planned study in the field, laboratory, or research setting; analyzing data to find patterns; summarizing results, drawing conclusions, and communicating findings both orally and in writing.

Ion: An atom or molecule that has lost or gained one or more electrons, giving it a positive or negative electrical charge.

Ionic bond: A type of chemical bond that often forms between metal and nonmetal ions through electrostatic attraction.

Ionic crystal: A formation of atoms held together by ionic bonds. Crystals of sodium chloride (salt), for example, does not form molecules. Rather, ions of sodium (Na) and chorine (Cl) are held together by ionic bonds in a three-dimensional ionic crystal.

Isotope: Isotopes are differing forms of the same element that have nuclei with the same number of protons (the same atomic number) but different numbers of neutrons. Therefore, isotopes have different mass numbers.

Kinetic energy: Energy of motion.

Law: An observed regularity of the natural world that scientists have observed repeatedly. Natural Laws can be used to accurately predict what will happen in many situations.

Life cycle: A description of the stages of development of an organism or planetary object such as a star.

Liquid: A fluid that takes the shape of the part of the container that it occupies, and that forms a distinct surface.

Logical argument: A set of one or more premises supported by evidence that leads to a clear conclusion.

Logical plan: A series of steps thoughtfully designed to meet a clear goal.

Magnifier: A convex lens which is used to produce an enlarged image of an object.

Manipulated (independent) variable: The factor of a system being investigated that is changed to determine that factor's relationship to the dependent (responding) variable.

Mantle: Earth's mantle is a viscous layer between the crust and the outer core. Earth's mantle is about 2,900 km thick and makes up about 70% of Earth's volume.

Mass: A measure of how much matter there is in an object.

Matter: Anything that has mass and that takes up space.

Mechanical mixing: Physical rearrangement of fluids or small particles by continuous movement.

Meiosis: A process of cell division that produces reproductive cells known as gametes. Each gamete contains only one set of the unpaired chromosomes and half as much genetic information as the original cell.

Melting point: The temperature at which a solid melts and becomes a liquid.

Mendelian Genetics: Fundamental concept of heredity that each organism has characteristics that are encoded in its genes and passed on from one generation to the next.

Metamorphic rock: Rocks modified by temperatures and pressures that are high enough to change the original minerals into other mineral types or into other forms of the same minerals.

Mitochondria: The organelle in eukaryotic cells that carry on cellular respiration, release energy from food molecules and storing it in ATP.

Mitosis: The production of two identical nuclei in one cell usually followed by cell division and the production of two cells with the same genetic makeup as the original cell.

Mixture: A substance made by combining two or more different materials without a chemical reaction occurring (the objects do not bond together).

Model: A simplified representation of a system. Models are useful for studying systems that are too big, too small, or too dangerous to study directly.

Molecule: A stable unit of two or more atoms held together by chemical bonds.

Moons: A natural satellite or moon is a celestial body that orbits a planet or smaller planetary body.

Motion: A constant change in the location of a body.

Mutation: Change to the nucleotide sequence of the genetic material of an organism.

Natural selection: The process by which heritable traits that are favored by environmental conditions become more common in successive generations, and heritable traits that are less favored by environmental conditions become less common. Over time, this process may result in the emergence of new species.

Natural world: Living and non-living aspects of the physical universe.

Neutron: A subatomic particle with no net electric charge and a mass slightly larger than that of a proton.

Niche: The position of a species or population in its ecosystem. A shorthand definition of niche is how and where an organism makes a living.

Nitrogen cycle: The biogeochemical cycle that describes the transformations of nitrogen and nitrogen-containing compounds in nature.

Nucleus: In physics: the central structure in an atom that contains neutrons and protons.

Nutrients: A food or chemicals that an organism needs to live and grow, or a substance used in an organism's metabolism that must be taken in from its environment.

Observation: The skill of recognizing and noting some fact or occurrence in the natural world. Observation includes the act of measuring.

Open system: A system in which matter may flow in and out, as opposed to a closed system in which matter may not flow in or out.

Open-ended explorations: Initial investigations of interesting phenomena without prior hypotheses about what may be discovered, or even what variables may be most important to observe and measure.

Orbit: The gravitationally curved path of one object around a point or another body, such as the orbit of a planet around a star.

Organism: A living thing such as an animal, plant, fungus, or microorganism. In at least some form, all organisms are capable of reacting to stimuli, reproduction, growth and maintenance as a stable whole.

Output: Matter, energy, or information that flows out of a system.

Patterns: Recurring events or objects that repeat in a predictable manner.

Phases of the Moon: Refers to the appearance of the illuminated portion of the Moon as seen by an observer, usually on Earth.

Phenomena: Events or objects occurring in the natural world.

Photosynthesis: A metabolic pathway that converts light energy into chemical energy. Its initial substrates are carbon dioxide and water; the energy source is sunlight (electromagnetic radiation); and the end products are oxygen and (energy-containing) carbohydrates, such as sucrose, glucose, or starch.

Physical change: Any change not involving modification of a substance's chemical identity, such as a change of state from solid to liquid, or liquid to gas.

Plutoid: A dwarf planet outside the orbit of Neptune. Plutoids have sufficient mass to be approximately spherical in shape, but not enough mass to have pulled in debris from the neighborhood of their orbit. (Pluto is both a dwarf planet and a plutoid.)

Population density: The number of individuals of a particular population living in a given amount of space.

Population growth: The rate at which the number of individuals in a population increases. Usually applies to a given ecosystem, but could refer to a region or the entire Earth.

Population: The collection organisms of a particular species that can breed and reproduce.

Precipitation: Any product of the condensation of atmospheric water vapor deposited on Earth's surface, such as rain, snow, or hail.

Predict/Prediction: Extrapolation to a future event or process based on theory, investigative evidence, or experience.

Principle: Rule or law concerning the functioning of systems of the natural world.

Producer: An organism that produces complex organic compounds from simple inorganic molecules using energy from light or inorganic chemical reactions.

Properties: Essential attributes shared by all members of a group.

Proton: A small particle with an electric charge of +1 elementary charge. It is often found as a subatomic particle in the nucleus of an atom, but is also stable in an ionic form in which it is also known as the hydrogen ion, H^+.

Question: A grammatical form of sentence that invites an answer.

Radiation: Energy in the form of rapidly propagating waves or particles emitted by a body as it changes from a higher energy state to a lower energy state.

Rain gauge: An instrument used to measure the amount of liquid precipitation over a set period of time.

Recombine: To disassemble, mix up, and put back together in a new arrangement.

Redesign: To create a new and improved solution to a problem after an earlier solution was tested and found to be lacking in some respects.

Relationship: Connections observed among systems, subsystems, or variables. Different types of relationships exist, including causal relationships and correlations.

Reliability: An attribute of any investigation that promotes consistency of results during repeated trials.

Responding (dependent) variable: The factor of a system being investigated that changes in response to the manipulated (independent) variable and is measured.

Ribosome: A cell organelle constructed in the nucleus. It consists of two subunits and functions as the site of protein synthesis in the cytoplasm.

Science: Knowledge of the natural world derived from systematic investigations; also, the activity of adding to the body of scientific knowledge.

Sediment: Any particulate matter that can be transported by fluid flow and which eventually is deposited as a layer of solid particles on the bed or bottom of a body of water or other liquid.

Sedimentary rock: Rocks formed by deposition of solid particles at the bottom of a body of water, followed by compaction and cementation. Common sedimentary rocks include shale, sandstone, and limestone.

Sexual reproduction: The production of new generations involving the combination of chromosomes from both a male and female parent. Because each parent contributes genetic information, the offspring of sexual reproduction are usually not identical to either parent.

Simulation: The imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviors of a selected physical or abstract system.

Skepticism: The attitude in scientific thinking that emphasizes that no fact or principle can be known with complete certainty; the tenet that all knowledge is uncertain.

Solar System: The Sun and those celestial objects bound to it by gravity, including eight planets, moons, dwarf planets, plutoids, asteroids, meteoroids, and other small bodies.

Solid: The state of matter characterized by resistance to deformation and changes of volume.

Solubility: The ability of a given substance to dissolve in a liquid.

Solution: 1. A device or process created through technological design to meet a human need or want. 2. A mixture in which particles of one substance are evenly distributed through another substance.

Species: A group of organisms capable of interbreeding and producing fertile offspring.

Speed: The rate or measure of the rate of motion. The distance travel divided by the time of travel.

Spherical: Shaped like a ball.

State of matter: Matter can exist in various states (or forms), which may depend on temperature and pressure. Traditionally, three states of matter are recognized: solid, which maintains a fixed volume and shape; liquid, which maintains a fixed volume but adopts the shape of its container; and gas, which occupies the entire volume available. Plasma, or ionized gas, is a fourth state that occurs at very high temperatures.

Steam: The scientific term "steam" is equivalent to water vapor, an invisible gas. In common language the term refers to visible mist made up of droplets of water that have condensed when steam meets cooler air. The distinction is not necessary at the elementary level.

Subsystem: The subset of interrelated parts within the larger system.

Sustainable development: Policies that enable people to obtain the resources they need today without limiting the ability of future generations to meet their own needs.

System: An assemblage of interrelated parts or conditions through which matter, energy, and information flow.

Technological design process: A sequence of steps used to define and solve a problem. The steps may include: defining the problem in terms of criteria and constraints, gathering information about the problem through research, generating ideas for possible solutions, synthesizing or selecting of one or more promising ideas or solutions, constructing a plan or model to test the proposed idea or solution, redesigning if needed and communicating the results.

Technology: Ways that people change the natural world to solve practical problems or improve the quality of life. Technology is the result of technological design.

Temperature: A physical property that determines the direction of heat flow between two objects placed in thermal contact. If no heat flow occurs, the two objects have the same temperature; otherwise, heat flows from the hotter object to the colder object.

Theory: An integrated, comprehensive explanation of many facts capable of generating hypotheses and testable predictions about the natural world.

Thermometer: An instrument for measuring temperature.

Tools: A device used to accomplish a task that a person alone cannot accomplish. The most basic tools are simple machines.

Transfer: Move from one place to another.

Transform: Change from one form to another.

Trials: Repetitions of data collection protocols in an investigation.

Tsunami: Unusually large waves created when a body of water, such as an ocean, is rapidly displaced by an earthquake, volcanic eruption, landslide, or other disruption (plural: tsunami).

Validity: An attribute of an investigation that describes the degree of confidence that data collected and logical inferences are accurate representations of the phenomena being investigated.

Variable: Any changed or changing factor used to test a hypothesis or prediction in an investigation that could affect the results.

Variation: A measure of the tendency of individuals in a population to differ from one another.

Velocity: A vector quantity whose magnitude is a body's speed and whose direction is the body's direction of motion.

Water vapor: The gas phase of water.

Wave amplitude: A measure of the maximum disturbance in the medium during one wave cycle (the maximum distance from the highest point of the crest to the equilibrium).

Wave frequency: The number of occurrences of a wave per unit time.

Wave: A disturbance that propagates through space and time, usually with transference of energy. Examples of wavelike phenomena are light, water waves, and sound waves.

Wavelength: The distance between two sequential crests (or troughs) of a wave.

Weathering: The decomposition of earth rocks, soils and their minerals through direct contact with the planet's atmosphere or biological agents.

Weight: The strength of the gravitational pull on an object.

Wind: The flow of air or other gases that compose an atmosphere.

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