WISCONSIN STANDARDS FOR

Science

Wisconsin Department of Public Instruction

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Wisconsin Department of Public Instruction
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Madison, Wisconsin

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Foreword

On November 13, 2017, I formally adopted the Wisconsin Standards for Science. This revised set of academic standards provides a foundational framework that identifies what students should know and be able to do in Science.

The adoption of the Wisconsin Standards for Science was part of a concerted effort led by Wisconsin educators and stakeholders who shared their expertise in science and teaching from kindergarten through higher education. The public and legislature provided feedback for the writing committee to consider as part of Wisconsin's Academic Standards review and revision process.

Science is an essential part of a comprehensive PK-12 education for all students. The knowledge, techniques, and citizenry skills gained through science education in Wisconsin schools support the overall goal of helping all students become college and career ready. Scientific literacy is a critical elementary of being able to make sense of the world around us, including the abundant information shared in our ever-changing world.

The knowledge and skills described provide a framework with actionable indicators for science classroom experiences. The key goal of the standards is for students make sense of phenomena and solve problems using scientific content understanding, practices, and ways of thinking. Teaching content for the purpose of "covering" a set range of topics is not the intent of these standards; instead, as research suggests, students should be learning scientific ideas through deeply exploring scientific phenomena and solving culturally relevant, local problems.

The Wisconsin Department of Public Instruction will continue to build on this work to support implementation of the standards with resources for the field. I am excited to share the Wisconsin Standards for Science, which aim to build science skills, knowledge, ways of thinking, and engagement opportunities for all Wisconsin students.

Carolyn Stanford Taylor
State Superintendent

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The Wisconsin Department of Public Instruction (DPI) wishes to acknowledge the ongoing work, commitment, and various contributions of individuals to revise our state's academic standards for science. Thank you to the State Superintendent's Standards Review Council for their work and guidance through the standards process. A special thanks to the Science Writing Committee for taking on this important project that will shape the classrooms of today and tomorrow. Thanks to the many staff members across the division and other teams at DPI who have contributed their time and talent to this project. Finally, a special thanks to Wisconsin educators, businesspeople, parents, and citizens who provided comment and feedback to drafts of these standards.

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Section I

Wisconsin's Approach to Academic Standards

Purpose of the Document

The purpose of this guide is to improve science education for students and for communities. The Wisconsin Department of Public Instruction (DPI) has developed standards to assist Wisconsin educators and stakeholders in understanding, developing and implementing science course offerings and curriculum in school districts across Wisconsin.

This publication provides a vision for student success and follows *The Guiding Principles for Teaching and Learning (2011)*. In brief, the principles are:

1. Every student has the right to learn.
2. Instruction must be rigorous and relevant.
3. Purposeful assessment drives instruction and affects learning.
4. Learning is a collaborative responsibility.
5. Students bring strengths and experiences to learning.
6. Responsive environments engage learners.

Program leaders will find the guide valuable for making decisions about:

- Program structure and integration
- Curriculum redesign
- Staffing and staff development
- Scheduling and student grouping
- Facility organization
- Learning spaces and materials development
- Resource allocation and accountability
- Collaborative work with other units of the school, district and community

What Are the Academic Standards?

Wisconsin Academic Standards specify what students should know and be able to do in the classroom. They serve as goals for teaching and learning. Setting high standards enables students, parents, educators, and citizens to know what students should have learned at a given point in time. In Wisconsin, all state standards serve as a model. Locally elected school boards adopt academic standards in each subject area to best serve their local communities. We must ensure that all children have equal access to high-quality education programs. Clear statements about what students must know and be able to do are essential in making sure our schools offer opportunities to get the knowledge and skills necessary for success beyond the classroom.

Adopting these standards is voluntary. Districts may use the academic standards as guides for developing local grade-by-grade level curriculum. Implementing standards may require some school districts to upgrade school and district curriculums. This may result in changes in instructional methods and materials, local assessments, and professional development opportunities for the teaching and administrative staff.

What is the Difference between Academic Standards and Curriculum?

Standards are statements about what students should know and be able to do, what they might be asked to do to give evidence of learning, and how well they should be expected to know or do it. Curriculum is the program devised by local school districts used to prepare students to meet standards. It consists of activities and lessons at each grade level, instructional materials, and various instructional techniques. In short, standards define what is to be learned at certain points in time, and from a broad perspective, what performances will be accepted as evidence that the learning has occurred. Curriculum specifies the details of the day-to-day schooling at the local level.

Developing the Academic Standards

DPI has a transparent and comprehensive process for reviewing and revising academic standards. The process begins with a notice of intent to review an academic area with a public comment period. The State Superintendent's Standards Review Council examines those comments and may recommend revision or development of standards in that academic area. The state superintendent authorizes whether or not to pursue a revision or development process. Following this, a state writing committee is formed to work on those standards for all grade levels. That draft is then made available for open review to get feedback from the public, key stakeholders, educators, and the Legislature with further review by the State Superintendent's Standards Review Council. The state superintendent then determines adoption of the standards.

Aligning for Student Success

To build and sustain schools that support every student in achieving success, educators must work together with families, community members, and business partners to connect the most promising practices to the most meaningful contexts. The release of the Wisconsin Standards for Science provides a set of important academic standards for school districts to implement. This is connected to a larger vision of every child graduating college, career, and community ready. The graphic below illustrates the relationship between academic standards and other critical principles and efforts that function together to educate every child to graduate future ready. Here, the vision and set of Guiding Principles form the foundation for building a supportive process for teaching and learning rigorous and relevant content. The following sections articulate this integrated approach to increasing student success in Wisconsin schools and communities.

Relating the Academic Standards to All Students

Grade-level standards should allow ALL students to engage, access, and be assessed in ways that fit their strengths, needs, and interests. This applies to the achievement of students with IEPs (individualized education plans), English learners, and gifted and talented pupils, consistent with all other students. Academic standards serve as the foundation for individualized programming decisions for all students.

Academic standards serve as a valuable basis for establishing concrete, meaningful goals as part of each student's developmental progress and demonstration of proficiency. Students with IEPs must be provided specially designed instruction that meets their individual needs. It is expected that each individual student with an IEP will require unique services and supports matched to their strengths and needs in order to close achievement gaps in grade-level standards. Alternate standards are only available for students with the most significant cognitive disabilities.

Gifted and talented students may achieve well beyond the academic standards and move into advanced grade levels or into advanced coursework.

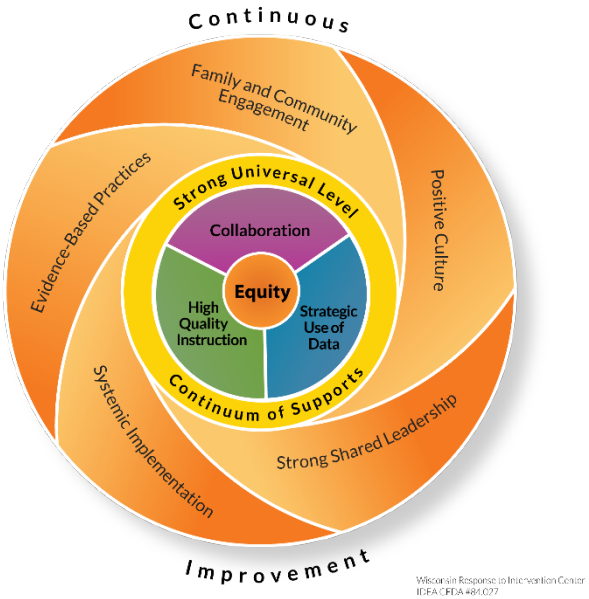
Our Vision: Every Child a Graduate, College and Career Ready

We are committed to ensuring every child graduates from high school academically prepared and socially and emotionally competent. A successful Wisconsin student is proficient in academic content and can apply their knowledge through skills such as critical thinking, communication, collaboration, and creativity. The successful student will also possess critical habits such as perseverance, responsibility, adaptability, and leadership. This vision for every child as a college, career, and community ready graduate guides our beliefs and approaches to education in Wisconsin.

Guided by Principles

All educational initiatives are guided and impacted by important and often unstated attitudes or principles for teaching and learning. *The Guiding Principles for Teaching and Learning (2011)* emerge from research and provide the touchstone for practices that truly affect the vision of Every Child a Graduate Prepared for College and Career. When made transparent, these principles inform what happens in the classroom, direct the implementation and evaluation of programs, and most importantly, remind us of our own beliefs and expectations for students.

Ensuring a Process for Student Success



For Wisconsin schools and districts, implementing the *Framework for Equitable Multi-Level Systems of Supports (2017)* means providing equitable services, practices, and resources to every learner based upon responsiveness to effective instruction and intervention. In this system, high-quality instruction, strategic use of data, and collaboration interact within a continuum of supports to facilitate learner success. Schools provide varying types of supports with differing levels of intensity to proactively and responsibly adjust to the needs of the whole child. These include the knowledge, skills, and habits learners need for success beyond high school, including developmental, academic, behavioral, social, and emotional skills.

Connecting to Content: Wisconsin Academic Standards

Within this vision for increased student success, rigorous, internationally benchmarked academic standards provide the content for high-quality curriculum and instruction and for a strategic assessment system aligned to those standards. With the adoption of the standards, Wisconsin has the tools to design curriculum, instruction, and assessments to maximize student learning. The standards articulate what we teach so that educators can focus on how instruction can best meet the needs of each student. When implemented within an equitable multi-level system of support, the standards can help to ensure that every child will graduate college and career ready.

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Section II

Wisconsin Standards for Science

What is Science Education?

Wisconsin defines science as an academic discipline encompassing the study of the natural world. Our science standards also include engineering applications, where science understanding informs problem-solving and design thinking within the human-built world. Engineering ideas encompass the interactions of science, technology, and society. The standards outlined here provide an important foundation to prepare students for post-secondary education, careers, and community involvement.

Science Education in Wisconsin

Science drives job growth and innovation throughout the economy and society. Demand for healthcare and other science, technology, engineering, and mathematics (STEM) based careers exceed other occupation categories, and this growth is projected to continue. The need for science education integrated with design thinking is increasing because all students will need some foundational knowledge in science and engineering to be future-ready problem solvers, regardless of their occupational path. Being competent citizens in a world of abundant information (and misinformation) requires strong scientific thinking skills.

These standards articulate end-of-grade level expectations. Some students - including students who receive special education services through an Individualized Education Program (IEP), students with gifts and talents, and English language learners - may benefit from additional supports or challenges. Some barriers to learning and engagement can be minimized through Universal Design for Learning (UDL). In addition, learning can be personalized through collaboration between educators, school staff, families, and students.

At the elementary level, science content and concepts can be integrated throughout the curriculum, but these standards require that students also have opportunities to engage in rigorous scientific investigation and argumentation from evidence. Teachers can effectively use science concepts and practices in instruction to develop foundational skills for secondary science. Research suggests that significant aspects of a scientific or STEM identity are formed by the end of the elementary years, making effective instruction through these grade levels critical (Dewitt, et al., 2010).

Wisconsin's Vision for Science

The Wisconsin vision for science learning is shaped by Wisconsin practitioners and experts, and is informed by work at the national level and in other states. The overarching goal for science is to work together to create a scientifically literate populace. Wisconsin's vision for K-12 science learning states that:

> "[By] the end of 12th grade, all students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of

scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology" (National Research Council, 2012).

Wisconsin's Approach to Academic Standards for Science

With the release of the *Wisconsin Standards for Science*, Wisconsin science teachers have access to the foundational knowledge and skills needed to educate students for college, career, and community readiness. Vetted by industry and education professionals, these academic standards guide Wisconsin schools, teachers, and community partners toward development and continuous improvement of world-class science courses.

Our standards built from the National Research Council's (NRC's) Framework for K-12 Science Education and the Next Generation Science Standards (NGSS Lead States, 2013). A group of national experts across science disciplines and engineering, along with science and engineering education, developed this framework and released it in 2012. Another group of experts, including representatives of 26 states, took that framework and developed the NGSS. Further information about this process can be found here. Several groups of Wisconsin educators provided feedback on multiple drafts of these standards. Based on survey data, by 2016, at least 80% of districts across Wisconsin had adopted the NGSS as their science standards or were using them to inform instruction in some way.

In 2017, Wisconsin educators, higher education experts, and industry professionals gathered to create the *Wisconsin Standards for Science* (WSS), heavily using these national documents. Notably, while some wording changes were made here and there for clarity, the core aspects of the WSS and the NGSS are the same. Districts can choose to solely the NGSS in place of the WSS and expect that students will be well-prepared for the Wisconsin Forward Exam.

Like the NGSS, the Wisconsin Standards for Science include three main dimensions:

- Crosscutting Concepts – big ideas of science that provide lenses for viewing phenomena and understanding problems in the world around us, and which apply across all areas of science and engineering;
- Science and Engineering Practices – the skills required for the work done in science;
- Disciplinary Core Ideas – content understanding across the disciplines of life science, physical science, earth and space science, and engineering.

Critically, these three dimensions are not meant to be taught in isolation. The standards are formed as instruction and learning integrate them into "three-dimensional learning" that requires students to use all three to make sense of phenomena and solve relevant problems.

The Wisconsin Standards for Science may be taught through a variety of classes and experiences. Each district, school, and program area should determine the means by which students meet these standards. The Forward Exam at grades 4 and 8, ACT Aspire at grades 9 and 10, and the ACT + Writing at grade 11 all provide useful large-scale information about learning related to these standards. Classroom and school/department-level assessments connected to these standards are other important aspects of the strategic assessment system that should be in place to fully gauge students' science learning and support individual students.

Standards Structure

All new Wisconsin standards are formatted from a common template to support educators in reading and interpreting them. The specific discipline is stated at the top of each template. In the case of the science standards, there are three sections (dimensions): crosscutting concept standards, science and engineering practice standards, and disciplinary core ideas (science and engineering content). The three sections are color coded. Crosscutting concept standards are in green. Science and engineering practice standards are in blue. Content standards are in orange. Every series of lessons should integrate these three dimensions; they should not be taught or assessed in isolation.

Structure, Development, and Language of the Science Content Standards

The science content standards are further divided into disciplinary core ideas in life science (LS); physical science (PS); earth and space science (ESS); and engineering, technology, and science applications (ETS). The figure below shows a sample standard from the life science content area:

Science: Disciplinary Core Ideas (DCI) — Life Science 1 (LS1) – Structures and Processes

Standard SCI.LS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *structures and processes (on a scale from molecules to organisms)* to make sense of phenomena and solve problems.

The code, "**Standard SCI.LS1"** is translated as follows: **Sci**ence.**L**ife **S**cience Content Area Standard **1**—which pertains to the content area of **structures and processes.**

The standards statements for content (disciplinary core ideas), practices, and crosscutting concepts are based on the foundational phrase, "Students use science and engineering practices, crosscutting concepts, and an understanding of content to make sense of phenomena and solve problems." Depending on the standard, the specific crosscutting concept, practice, or content topic will appear in bold. In this case, the content of "structures and processes (on a scale from molecules to organisms)," is italicized as it is the focus of the following section (LS1).

These standards statements emphasize students should be engaging in three-dimensional science learning from kindergarten through grade 12, meaning they learn the content by engaging in the scientific and engineering practices while using the perspectives of the crosscutting concepts to think like scientists.

Each content standard statement is further divided into **learning priorities** and **performance indicators**. In the figure below, the code **SCI.LS1.A** refers to learning priority A of life science standard statement 1. Each standard statement has from 1-5 learning priorities, which are subareas of the overarching content, practice, or crosscutting concept on the page. The **performance indicators** provide a learning progression from grade band to grade band for each learning priority. **Notably**, these disciplinary core ideas statements only become "performance indicators" when placed in the context of the standards statement at the top of each page: "Students use science and engineering practices, crosscutting concepts, and an understanding of [*insert content*] to make sense of phenomena and solve problems." Each performance indicator is associated with a suggested grade level within the elementary school grade bands; the code for the performance indicator notes the appropriate grade level at the end. For example, **SCI.LS1.A.1** refers to the developmentally appropriate understanding of

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS1.A: Structure and Function	SCI.LS1.A.1 All organisms have external parts that they use to perform daily functions.	SCI.LS1.A.4 Plants and animals have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	SCI.LS1.A.m All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	SCI.LS1.A.h Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.
SCI.LS1.B: Growth and Development of Organisms	SCI.LS1.B.1 Parents and offspring often engage in behaviors that help the offspring survive.	SCI.LS1.B.3 Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.	SCI.LS1.B.m Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors.	SCI.LS1.B.h Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.

structure and function for the K-2 grade band, and it is suggested that this content be learned in grade 1. These grade levels are recommended to support consistency across the state, state standardized assessment preparation, and student transfers between districts. With local control, districts can assign performance indicators to elementary grade levels that best fit their needs.

Performance indicators for the middle school and high school grade bands are not associated with suggested grade levels, so the grade level codes for these grade bands are "m" for middle school and "h" for high school. Some districts may choose an integrated course format while others may choose to organize classes by discipline. There is not a recommended method. Appendix K of the *Next Generation Science Standards* includes several ideas for structuring secondary science courses.

The high school standards include content, skills, and ways of thinking (i.e. disciplinary core ideas, science and engineering practices, and crosscutting concepts), forming the core learning for *all* students. Advanced and elective science coursework should move beyond the content noted here, though the practice and crosscutting concept standards should remain an integral part of instruction.

It bears repeating that all standards statements have a similar structure with a blank that is filled by a specific grade level disciplinary core idea from each learning priority. The performance indicators should be read as appropriately filling in the overarching standards statement at the beginning of each section. For example, performance indicator **SCI.LS1.A.1** can be read as "Students use science and engineering practices, crosscutting concepts, and an understanding that all organisms have external parts that they use to perform daily functions to make sense of phenomena and solve problems." When considered within this three-dimensional framework, performance indicators provide a measurable component(s) for educators to use in assessing student learning.

Some learning priorities boxes are intentionally left blank where it is not developmentally appropriate to teach a particular science topic at that grade level.

It is important to note that there are no performance indicators listed for Four-Year-Old Kindergarten (4K). Our committee suggests that educators use the Wisconsin Model Early Learning Standards to guide their work as they take advantage of the natural connections to science that come up daily in an effective 4K experience. Some suggestions for 4K teachers include supporting student experiences by encouraging students to ask questions and make observations as they play. 4K classes in which teachers ask, "What did you notice?" "What do you wonder?" "What does this remind you of?" and "What does it feel like, sound like, smell like, taste like, look like?" are more likely to come alive with authentic exploration. Such exploration and

wondering allows young children opportunities to figure things out and develop their own explanations as they interact with their world.

As stated earlier, these standards are designed to encourage instruction and learning that is "**three dimensional**," i.e., includes content taught through engagement in science and engineering practices in the context of crosscutting concepts. This three dimensionality is a new means of doing business in the world of science education. The standards documents include performance indicators that are provided as examples of ways to weave together particular content, practices, and modes of thinking for the purpose of assessing student learning in a three dimensional context. With the exception of the ETS3 standards, which were developed in Wisconsin, these example performance indicators come from the *Next Generation Science Standards*.

SCI.LS1: Example Three-Dimensional Performance Indicators

Grades K-2	K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive. 1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants or animals use their external parts to help them survive, grow, and meet their needs. 1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

While these performance indicators provide guidance for the development of the 4th and 8th grade Forward Exam, they are not meant to dictate curriculum and instruction. That development process should be guided by local leaders discussing how to best connect the three dimensions based on local instructional preferences and students' needs. Groups of science educators may wish to create their own three dimensional performance indicators. See the figure below for the K-2 LS1 examples.

The statements are coded to indicate grade levels and the associated content standard. For example, the performance indicator **K-LS1-1** was created as an example of a kindergarten (K) indicator associated with standard LS1. To assist in labeling and communication, the number at the end specifies that this is kindergarten sample performance indicator number 1.

Structure, Development, and Language of the Crosscutting Concepts Standards

There are seven crosscutting concepts standards built from Appendix G of the *Next Generation Science Standards*. These crosscutting concepts are lenses through which scientists and engineers view phenomena and problems. Thus, they should form the basis for the types of questions students ask and the analysis students do as they engage in authentic professional practice to understand core science ideas. The standards page starts with a foundational, three-dimensional phrase, and each performance indicator should be imbedded into this phrase. For instance, the example below states, "Students use science and engineering

practices, disciplinary core ideas, and ***patterns*** to make sense of phenomena and solve problems." For a K-2 teacher, they would further put their specific crosscutting concept statement into this sentence, so it would read, "Students use science and

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC1: Patterns	SCI.CC1.K-2 Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	SCI.CC1.3-5 Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and use these patterns to make predictions.	SCI.CC1.m Students recognize macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human-designed systems. They use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.	SCI.CC1.h Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale, thus requiring improved investigations and experiments. They use mathematical representations to identify and analyze patterns of performance in order to reengineer a designed system.

engineering practices and disciplinary core **ideas to recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence**. Therefore, every performance indicator statement in each grade band would be read within this phrase, taking the place of the segment in bold. The coding of the crosscutting concepts performance indicators follows the same pattern as the content standards (disciplinary core ideas), with one exception. Since the crosscutting concept (CC) standards are not divided into separate "learning priorities," the codes have one fewer numerical part. A sample (CC1: Patterns) is shown in the figure below.

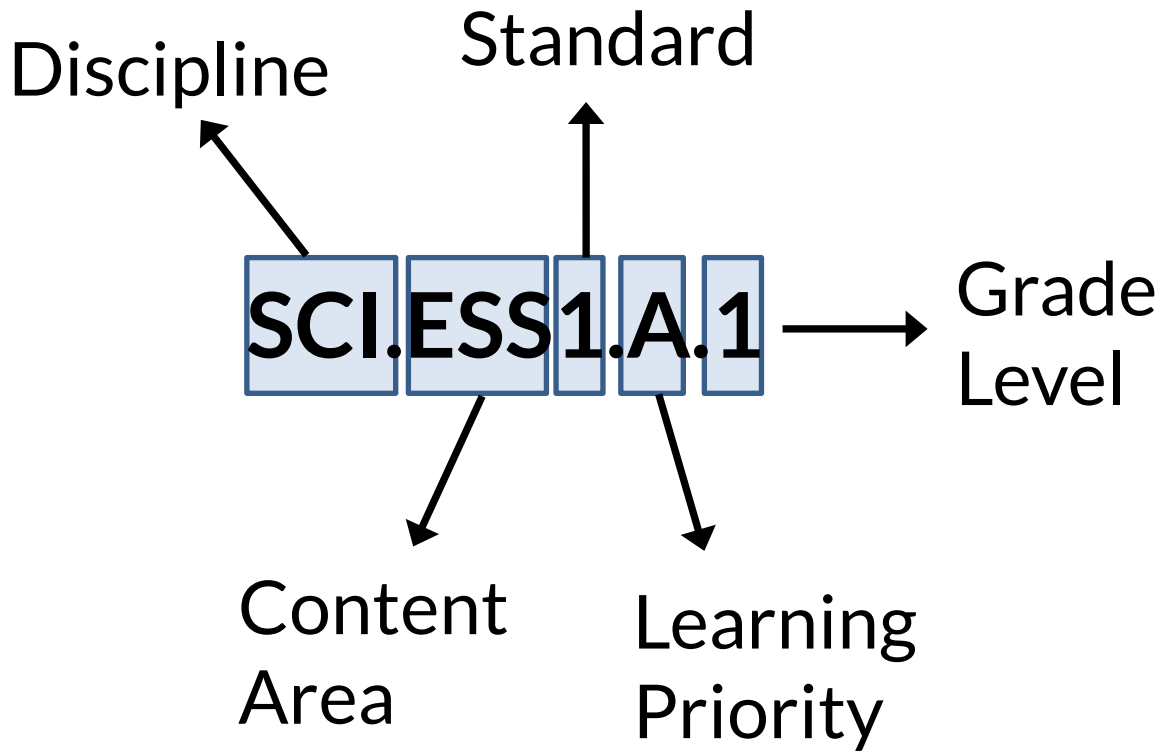
Structure, Development, and Language of the Science and Engineering Practice Standards

There are eight science and engineering practice standards built from Appendix F of the *Next Generation Science Standards*. These practice standards detail the work of scientists and engineers. They suggest the types of skills students should be using as they learn core concepts and how to think like scientists and engineers. Each standard is further divided into learning priorities and performance indicators. The standards page starts with a foundational, three-dimensional phrase, and each performance indicator should be read as part of this phrase. For example, the standard below states, "Students ***ask questions and define***

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP1.A: Asking Questions	SCI.SEP1.A.K-2 Students ask simple descriptive questions that can be tested. This includes the following: Ask questions based on observations to find more information about the natural world. Ask or identify questions that can be answered by an investigation.	SCI.SEP1.A.3-5 Students ask questions that specify qualitative relationships. This includes the following: Ask questions about what would happen if a variable is changed. Identify scientific (testable) and non-scientific (non-testable) questions. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	SCI.SEP1.A.m Students ask questions to specify relationships between variables and clarify arguments and models. This includes the following: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify or seek additional information. Ask questions to identify and clarify evidence and the premise(s) of an argument.	SCI.SEP1.A.h Students ask questions to formulate, refine, and evaluate empirically testable questions. This includes the following: Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information. Ask questions that arise from examining models or theories to clarify and seek additional information and relationships.

problems, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems." Like the above standards dimensions, each performance indicator statement would be read within this phrase, using the grade-level statement in place of the segment in bold. The science and engineering practices are not intended as the focus of a stand-alone lesson or unit, but should be integrated with the other two dimensions in the course of science instruction. The coding of the science and engineering practice standards statements, learning priorities, and performance indicators follows the same pattern as the content standards with one exception: The performance indicators for K-2 and 3-5 are identified by grade band and not grade level, as is done with the disciplinary core ideas. A sample is shown in the figure below.

Summary: How to read the standards codes for a performance indicator



"Content areas" in this code structure include:

- LS - Life Science
- PS - Physical Science
- ESS - Earth and Space Science
- ETS - Engineering, Technology, and Society
- SEP - Science and Engineering Practices
- CC - Crosscutting Concepts

Standards Formatting

- **Standard**: Broad statement that tells what students are expected to know or be able to do
- **Learning priority**: Breaks down the broad statement into smaller learning pieces
- **Performance indicator by grade level or grade band**: Measurable degree to which a standard has been developed or met

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Section III

Science Standards

Science: Crosscutting Concepts (CC) — Patterns

Standard SCI.CC1: Students use science and engineering practices, disciplinary core ideas, and *patterns* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC1: Patterns	SCI.CC1.K-2 Students recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	SCI.CC1.3-5 Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and use these patterns to make predictions.	SCI.CC1.m Students recognize macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human-designed systems. They use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.	SCI.CC1.h Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They recognize classifications or explanations used at one scale may not be useful or need revision using a different scale, thus requiring improved investigations and experiments. They use mathematical representations to identify and analyze patterns of performance in order to reengineer a designed system.

Science: Crosscutting Concepts (CC) — Cause and Effect

Standard SCI.CC2: Students use science and engineering practices, disciplinary core ideas, and *cause and effect* relationships to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC2: Cause and Effect	SCI.CC2.K-2 Students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes.	SCI.CC2.3-5 Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity may or may not signify a cause and effect relationship.	SCI.CC2.m Students classify relationships as causal or correlational, and recognize correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be explained using probability.	SCI.CC2.h Students understand empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.

Science: Crosscutting Concepts (CC) — Scale, Proportion, and Quantity

Standard SCI.CC3: Students use science and engineering practices, disciplinary core ideas, and an understanding of *scale, proportion and quantity* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC3: Scale, Proportion, and Quantity	SCI.CC3.K-2 Students use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects. They use standard units to measure length.	SCI.CC3.3-5 Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as mass, time, temperature, and volume.	SCI.CC3.m Students observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.	SCI.CC3.h Students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. They use orders of magnitude to understand how a model at one scale relates to a model at another scale. They use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Science: Crosscutting Concepts (CC) — Systems and System Models

Standard SCI.CC4: Students use science and engineering practices, disciplinary core ideas, and an understanding of *systems and system models* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC4: Systems and System Models	SCI.CC4.K-2 Students understand objects and organisms can be described in terms of their parts and that systems in the natural and designed world have parts that work together.	SCI.CC4.3-5 Students understand a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They also describe a system in terms of its components and their interactions.	SCI.CC4.m Students understand systems may interact with other systems: they may have sub-systems and be a part of larger complex systems. They use models to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems. They also learn that models are limited in that they only represent certain aspects of the system under study.	SCI.CC4.h Students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also use models and simulations to predict the behavior of a system, and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models. They also design systems to do specific tasks.

Science: Crosscutting Concepts (CC) — Energy and Matter

Standard SCI.CC5: Students use science and engineering practices, disciplinary core ideas, and an understanding of *energy and matter* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC5: Energy and Matter	SCI.CC5.K-2 Students observe objects may break into smaller pieces, be put together into larger pieces, or change shapes.	SCI.CC5.3-5 Students understand matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes, recognizing the total mass of substances does not change. *Note: In this grade band, students are not expected to be able to differentiate between mass and weight.*	SCI.CC5.m Students understand matter is conserved because atoms are conserved in physical and chemical processes. They also understand that within a natural or designed system the transfer of energy drives the motion and cycling of matter. Energy may take different forms (e.g. energy in fields, thermal energy, and energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.	SCI.CC5.h Students understand that the total amount of energy and matter in closed systems is conserved. They describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also learn that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Science: Crosscutting Concepts (CC) — Structure and Function

Standard SCI.CC6: Students use science and engineering practices, disciplinary core ideas, and an understanding of *structure and function* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC6: Structure and Function	SCI.CC6.K-2 Students observe the shape and stability of structures of natural and designed objects are related to their function(s).	SCI.CC6.3-5 Students understand different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions.	SCI.CC6.m Students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among their parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	SCI.CC6.h Students investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system's function and solve a problem. They infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.

Science: Crosscutting Concepts (CC) — Stability and Change

Standard SCI.CC7: Students use science and engineering practices, disciplinary core ideas, and an understanding of *stability and change* to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
CC7: Stability and Change	SCI.CC7.K-2 Students observe some things stay the same while other things change, and things may change slowly or rapidly.	SCI.CC7.3-5 Students measure change in terms of differences over time, and observe that change may occur at different rates. They understand some systems appear stable, but over long periods of time they will eventually change.	SCI.CC7.m Students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. They understand changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.	SCI.CC7.h Students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Science: Science and Engineering Practices (SEP) — Asking Questions and Defining Problems

Standard SCI.SEP1: Students *ask questions and define problems*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP1.A: Asking Questions	SCI.SEP1.A.K-2 Students ask simple descriptive questions that can be tested. This includes the following: Ask questions based on observations to find more information about the natural world. Ask or identify questions that can be answered by an investigation.	SCI.SEP1.A.3-5 Students ask questions that specify qualitative relationships. This includes the following: Ask questions about what would happen if a variable is changed. Identify scientific (testable) and non-scientific (non-testable) questions. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	SCI.SEP1.A.m Students ask questions to specify relationships between variables and clarify arguments and models. This includes the following: Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify or seek additional information. Ask questions to identify and clarify evidence and the premise(s) of an argument. Ask questions to determine relationships between independent and dependent variables and relationships in models.	SCI.SEP1.A.h Students ask questions to formulate, refine, and evaluate empirically testable questions. This includes the following: Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information. Ask questions that arise from examining models or theories to clarify and seek additional information and relationships. Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. Ask questions to clarify and refine a model or an explanation.

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Science: Science and Engineering Practices (SEP) — Asking Questions and Defining Problems

Standard SCI.SEP1: Students *ask questions and define problems*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP1.A: Asking Questions (cont'd)			SCI.SEP1.A.m Ask questions to clarify or refine a model, an explanation, or an engineering problem. Ask questions that require sufficient and appropriate empirical evidence to answer. Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. Ask questions that challenge the premise(s) of an argument or the interpretation of a data set.	SCI.SEP1.A.h Evaluate a question to determine if it is testable and relevant. Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. Ask and evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.

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Science: Science and Engineering Practices (SEP) — Asking Questions and Defining Problems

Standard SCI.SEP1: Students *ask questions and define problems*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP1.B: Defining Problems	SCI.SEP1.B.K-2 Students define simple problems that can be solved through the development of a new or improved object or tool.	SCI.SEP1.B.3-5 Students use prior knowledge to describe and define simple design problems that can be solved through the development of an object, tool, process, or system. They include several criteria for success and constraints on materials, time, or cost.	SCI.SEP1.B.m Students define a design problem that can be solved through the development of an object, tool, process, or system, and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	SCI.SEP1.B.h Students formulate, refine, and evaluate design problems using models and simulations. This includes the following: Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and environmental considerations. Clarify and refine an engineering problem.

Science: Science and Engineering Practices (SEP) — Developing and Using Models

Standard SCI.SEP2: Students *develop and use models*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP2: Developing and Using Models	SCI.SEP2.K-2 Students use and develop models (i.e., diagrams, drawings, physical replicas, dioramas, dramatizations, or storyboards) that represent concrete events or design solutions. This includes the following: Distinguish between a model and the actual object, process, or events the model represents. Compare models to identify common features and differences. Develop or use models to represent amounts, relationships, relative scales (bigger, smaller), and patterns in the natural and designed world(s).	SCI.SEP2.3-5 Students build and revise simple models and use models to represent events and design solutions. This includes the following: Identify limitations of models. Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. Develop and/or use models to describe or predict phenomena.	SCI.SEP2.m Students develop, use, and revise models to describe, test, and predict more abstract phenomena and design systems. This includes the following: Evaluate limitations of a model for a proposed object or tool. Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. Use and develop a model of simple systems with uncertain and less predictable factors.	SCI.SEP2.h Students use, synthesize, and develop models to predict and show relationships among variables and between systems and their components in the natural and designed world. This includes the following: Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria. Design a test of a model to ascertain its reliability. Develop, revise, and use models based on evidence to illustrate and predict the relationships between systems or between components of a system.

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Science: Science and Engineering Practices (SEP) — Developing and Using Models

Standard SCI.SEP2: Students *develop and use models*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP2: Developing and Using Models (cont'd)	SCI.SEP2.K-2 Develop a simple model based on evidence to represent a proposed object or tool.	SCI.SEP2.3-5 Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	SCI.SEP2.m Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. Develop and use a model to predict and describe phenomena. Develop a model to describe unobservable mechanisms. Develop and use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	SCI.SEP2.h Develop and use multiple types of models to provide mechanistic accounts and predict phenomena. Move flexibly between these model types based on merits and limitations. Develop a complex model that allows for manipulation and testing of a proposed process or system. Develop and use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and solve problems.

Science: Science and Engineering Practices (SEP) — Planning and Conducting Investigations

Standard SCI.SEP3: Students *plan and conduct investigations*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP3: Planning and Conducting Investigations	SCI.SEP3.K-2 Students plan and carry out simple investigations, based on fair tests, which provide data to support explanations or design solutions. This includes the following: With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. Evaluate different ways of observing and measuring a phenomenon to determine which way can answer the question being studied.	SCI.SEP3.3-5 Students plan and carry out investigations that control variables and provide evidence to support explanations or design solutions. This includes the following: Collaboratively plan and conduct an investigation to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. Evaluate appropriate methods and tools for collecting data. Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	SCI.SEP3.m Students plan and carry out investigations that use multiple variables and provide evidence to support explanations or solutions. This includes the following: Individually and collaboratively plan an investigation, identifying: independent and dependent variables and controls, tools needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. Conduct an investigation. Evaluate and revise the experimental design to produce data that serve as the basis for evidence to meet the goals of the investigation.	SCI.SEP3.h Students plan and carry out investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models: This includes the following: Individually and collaboratively plan an investigation or test a design to produce data that can serve as evidence to build and revise models, support explanations for phenomena, and refine solutions to problems. Consider possible variables or effects and evaluate the investigation's design to ensure variables are controlled. Individually and collaboratively plan and conduct an investigation to produce data to serve as the basis for evidence.

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Science: Science and Engineering Practices (SEP) — Planning and Conducting Investigations

Standard SCI.SEP3: Students *plan and conduct investigations*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP3: Planning and Conducting Investigations (cont'd)	SCI.SEP3.K-2 Make observations (firsthand or from media) and measurements to collect data that can be used to make comparisons. Make observations (firsthand or from media) and measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.	SCI.SEP3.3-5 Make predictions about what would happen if a variable changes. Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.	SCI.SEP3.m Evaluate the accuracy of various methods for collecting data. Collect data under a range of conditions that serve as the basis for evidence to answer scientific questions or test design solutions. Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.	SCI.SEP3.h In the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. Consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly. Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. Select appropriate tools to collect, record, analyze, and evaluate data.

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Science: Science and Engineering Practices (SEP) — Planning and Conducting Investigations

Standard SCI.SEP3: Students *plan and conduct investigations*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP3: Planning and Conducting Investigations (cont'd)				SCI.SEP3.h Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points, or to improve performance relative to criteria for success.

Science: Science and Engineering Practices (SEP) — Analyze and Interpret Data

Standard SCI.SEP4: Students *analyze and interpret data*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP4: Analyzing and Interpreting Data	SCI.SEP4.K-2 Students collect, record, and share observations. This includes the following: Record information (observations, thoughts, and ideas). Use and share pictures, drawings, or writings of observations. Use observations (firsthand or from media) to describe patterns or relationships in the natural and designed worlds in order to answer scientific questions and solve problems. Compare predictions (based on prior experiences) to what occurred (observable events).	SCI.SEP4.3-5 Students begin to use quantitative approaches to collect data and conduct multiple trials of qualitative observations. (When possible, digital tools should be used.) This includes the following: Represent data in tables or various graphical displays (bar graphs, pictographs, and pie charts) to reveal patterns that indicate relationships. Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, or computation. Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.	SCI.SEP4.m Students extend quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. This includes the following: Construct, analyze, or interpret graphical displays of data and large data sets to identify linear and nonlinear relationships. Use graphical displays (e.g., maps, charts, graphs, and tables) of large data sets to identify temporal and spatial relationships. Distinguish between causal and correlational relationships in data.	SCI.SEP4.h Students engage in more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. This includes the following: Analyze data using tools, technologies, and models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible.

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Science: Science and Engineering Practices (SEP) — Analyze and Interpret Data

Standard SCI.SEP4: Students *analyze and interpret data*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP4: Analyzing and Interpreting Data (cont'd)	SCI.SEP4.K-2 Analyze data from tests of an object or tool to determine if the object or tool works as intended.	SCI.SEP4.3-5 Analyze data to refine a problem statement or the design of a proposed object, tool, or process. Use data to evaluate and refine design solutions.	SCI.SEP4.m Analyze and interpret data to provide evidence for explanations of phenomena. Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible. Consider limitations of data analysis (e.g., measurement error), and seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials). Analyze and interpret data to determine similarities and differences in findings.	SCI.SEP4.h Concepts should include determining the fit of functions, slope, and intercepts to data, along with correlation coefficients when the data is linear. Consider and address more sophisticated limitations of data analysis (e.g., sample selection) when analyzing and interpreting data. Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. Evaluate the impact of new data on a working explanation or model of a proposed process or system.

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Science: Science and Engineering Practices (SEP) — Analyze and Interpret Data

Standard SCI.SEP4: Students *analyze and interpret data*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP4: Analyzing and Interpreting Data (cont'd)			SCI.SEP4.m Analyze data to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.	SCI.SEP4.h Analyze data to optimize design features or characteristics of system components relative to criteria for success.

Science: Science and Engineering Practices (SEP) — Mathematics and Computational Thinking

Standard SCI.SEP5: Students use *mathematics and computational thinking*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP5: Qualitative and Quantitative Data	SCI.SEP5.K-2 Students recognize that mathematics can be used to describe the natural and designed world. This includes the following: Use counting and numbers to identify and describe patterns in the natural and designed worlds. Describe, measure, or compare quantitative attributes of different objects and display the data using simple graphs. Use qualitative and/or quantitative data to compare two alternative solutions to a problem.	SCI.SEP5.3-5 Students extend quantitative measurements to a variety of physical properties, using computation and mathematics to analyze data and compare alternative design solutions. This includes the following: Organize simple data sets to reveal patterns that suggest relationships. Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. Create and use graphs or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	SCI.SEP5.m Students identify patterns in large data sets and use mathematical concepts to support explanations and arguments. This includes the following: Decide when to use qualitative vs. quantitative data. Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. Use mathematical representations to describe and support scientific conclusions and design solutions. Create algorithms (a series of ordered steps) to solve a problem.	SCI.SEP5.h Students use algebraic thinking and analysis, a range of linear and nonlinear functions (including trigonometric functions, exponentials, and logarithms), and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. This includes the following: Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success. Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

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Science: Science and Engineering Practices (SEP) — Mathematics and Computational Thinking

Standard SCI.SEP5: Students use *mathematics and computational thinking*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP5: Qualitative and Quantitative Data (cont'd)			SCI.SEP5.m Apply mathematical concepts and processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems. Use digital tools and mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	SCI.SEP5.h Use mathematical, computational, and algorithmic representations of phenomena or design solutions to describe and support claims and explanations. Apply techniques of algebra and functions to represent and solve scientific and engineering problems. Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model "makes sense" by comparing the outcomes with what is known about the real world.

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Science: Science and Engineering Practices (SEP) — Mathematics and Computational Thinking

Standard SCI.SEP5: Students use *mathematics and computational thinking*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP5: Qualitative and Quantitative Data (cont'd)				SCI.SEP5.h Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m^3, acre-feet, and others).

Science: Science and Engineering Practices (SEP) — Construct Explanations and Design Solutions

Standard SCI.SEP6: Students *construct explanations and design solutions*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP6.A: Construct an Explanation	SCI.SEP6.A.K-2 Students use evidence and ideas in constructing evidence-based accounts of natural phenomena. This includes the following: Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	SCI.SEP6.A.3-5 Students use evidence to construct explanations that specify variables which describe and predict phenomena. This includes the following: Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation. Identify the evidence that supports particular points in an explanation.	SCI.SEP6.A.m Students construct explanations supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Construct an explanation that includes qualitative or quantitative relationships between variables that predict and describe phenomena. Construct an explanation using models or representations.	SCI.SEP6.A.h Students create explanations that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Make quantitative and qualitative claims regarding the relationship between dependent and independent variables. Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources, including students' own investigations, models, theories, simulations, and peer review.

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Science: Science and Engineering Practices (SEP) — Construct Explanations and Design Solutions

Standard SCI.SEP6: Students *construct explanations and design solutions*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP6.A: Construct an Explanation (cont'd)			SCI.SEP6.A.m Construct a scientific explanation based on valid and reliable evidence obtained from sources, including the students' own experiments. Solutions should build on the following assumption: theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Apply scientific ideas, principles, and evidence to construct, revise, or use an explanation for real world phenomena, examples, or events.	SCI.SEP6.A.h Explanations should reflect the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Apply scientific ideas, principles, and evidence to provide an explanation of phenomena taking into account possible, unanticipated effects. Apply scientific reasoning, theory, and models to link evidence to the claim and to assess the extent to which the reasoning and data support the explanation.

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Science: Science and Engineering Practices (SEP) — Construct Explanations and Design Solutions

Standard SCI.SEP6: Students *construct explanations and design solutions*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP6.B: Design Solutions	SCI.SEP6.B.K-2 Students use evidence and ideas in designing solutions. This includes the following: Use tools and materials to design and/or build a device that solves a specific problem or a solution to a specific problem. Generate and compare multiple solutions to a problem.	SCI.SEP6.B.3-5 Students use evidence to create multiple solutions to design problems. This includes the following: Apply scientific ideas to solve design problems. Generate multiple solutions to a problem and compare how well they meet the criteria and constraints.	SCI.SEP6.B.m Students design solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system. Undertake a design project, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints. Optimize performance of a design by prioritizing criteria, making trade-offs, testing, revising, and retesting.	SCI.SEP6.B.h Students create designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following: Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, and prioritized criteria. Consider trade-offs. Apply scientific ideas, principles, and evidence to solve design problems, taking into account possible unanticipated effects.

Science: Science and Engineering Practices (SEP) — Engage in Argument from Evidence

Standard SCI.SEP7: Students *engage in argument from evidence*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP7: Arguing from Evidence	SCI.SEP7.K-2 Students compare ideas and representations about the natural and designed world. This includes the following: Identify arguments that are supported by evidence. Distinguish between explanations that account for all gathered evidence and those that do not. Analyze why some evidence is relevant to a scientific question and some is not. Distinguish between opinions and evidence in one's own explanations. Listen actively to arguments to indicate agreement or disagreement based on evidence, or to retell the main points of the argument.	SCI.SEP7.3-5 Students critique the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. This includes the following: Compare and refine arguments based on an evaluation of the evidence presented. Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.	SCI.SEP7.m Students construct a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. This includes the following. Compare and critique two arguments on the same topic. Analyze whether they emphasize similar or different evidence and interpretations of facts. Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	SCI.SEP7.h Students use appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science. This includes the following: Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

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Science: Science and Engineering Practices (SEP) — Engage in Argument from Evidence

Standard SCI.SEP7: Students *engage in argument from evidence*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP7: Arguing from Evidence (cont'd)	SCI.SEP7.K-2 Construct an argument with evidence to support a claim. Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	SCI.SEP7.3-5 Construct and/or support an argument with evidence, data, or a model. Use data to evaluate claims about cause and effect. Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	SCI.SEP7.m Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system. Based the argument on empirical evidence concerning whether or not the technology meets relevant criteria and constraints. Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	SCI.SEP7.h Respectfully provide and receive critiques on scientific arguments by probing reasoning and evidence, by challenging ideas and conclusions, by responding thoughtfully to diverse perspectives, and by determining what additional information is required to resolve contradictions. Construct, use, and present oral and written arguments or counter-arguments based on data and evidence. Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.

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Science: Science and Engineering Practices (SEP) — Engage in Argument from Evidence

Standard SCI.SEP7: Students *engage in argument from evidence*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP7: Arguing from Evidence (cont'd)				SCI.SEP7.h Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments. Consider relevant factors (e.g. economic, societal, environmental, and ethical considerations).

Science: Science and Engineering Practices (SEP) — Obtain, Evaluate, and Communicate Information

Standard SCI.SEP8: Students *obtain, evaluate, and communicate information*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP8: Obtaining, Evaluating, and Communicating Information	SCI.SEP8.K-2 Students use observations and texts to communicate new information. This includes the following: Read developmentally-appropriate texts or use media to obtain scientific and technical information. Use the information to determine patterns in or evidence about the natural and designed worlds. Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.	SCI.SEP8.3-5 Students evaluate the merit and accuracy of ideas and methods. This includes the following: Read and comprehend grade-appropriate complex texts and other reliable media to summarize and obtain scientific and technical ideas, and describe how they are supported by evidence. Compare and/or combine information across complex texts and other reliable media to support the engagement in scientific and engineering practices.	SCI.SEP8.m Students evaluate the merit and validity of ideas and methods. This includes the following: Critically read scientific texts adapted for classroom use to determine the central ideas, to obtain scientific and technical information, and to describe patterns in and evidence about the natural and designed world(s). Clarify claims and findings by integrating text-based qualitative and quantitative scientific information with information contained in media and visual displays.	SCI.SEP8.h Students evaluate the validity and reliability of claims, methods, and designs. This includes the following: Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions, and to obtain scientific and technical information. Summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

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Science: Science and Engineering Practices (SEP) — Obtain, Evaluate, and Communicate Information

Standard SCI.SEP8: Students *obtain, evaluate, and communicate information*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP8: Obtaining, Evaluating, and Communicating Information (cont'd)	SCI.SEP8.K-2 S Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering scientific questions or supporting scientific claims. Communicate information or design ideas and solutions with others in oral or written forms. Use models, drawings, writing, or numbers that provide detail about scientific ideas, practices, or design ideas.	SCI.SEP8.3-5 Combine information in written text with that contained in corresponding tables, diagrams, or charts to support the engagement in other scientific and engineering practices. Obtain and combine information from books or other reliable media to explain phenomena or solutions to a design problem. Communicate scientific and technical information orally or in written formats, including various forms of media, which may include tables, diagrams, and charts.	SCI.SEP8.m Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication. Describe how they are supported or not supported by evidence and evaluate methods used. Evaluate data, hypotheses, and conclusions in scientific and technical texts in light of competing information or accounts. Communicate scientific and technical information (e.g. about a proposed object, tool, process, or system) in writing and through oral presentations.	SCI.SEP8.h Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively, or text-based) in order to address a scientific question or solve a problem. Gather, read, and evaluate scientific and technical information from multiple authoritative sources, assessing the evidence and usefulness of each source. Synthesize and evaluate the validity and reliability of multiple claims, methods, or designs that appear in scientific and technical texts or media reports. Verify the data when possible.

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Science: Science and Engineering Practices (SEP) — Obtain, Evaluate, and Communicate Information

Standard SCI.SEP8: Students *obtain, evaluate, and communicate information*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SEP8: Obtaining, Evaluating, and Communicating Information (cont'd)				SCI.SEP8.h Communicate scientific and technical information in multiple formats, including orally, graphically, textually, and mathematically. Examples of information could include ideas about phenomena or the design and performance of a proposed process or system.

Science: Disciplinary Core Ideas (DCI) — Life Science 1 (LS1) – Structures and Processes

Standard SCI.LS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *structures and processes (on a scale from molecules to organisms)* to make sense of phenomena and solve problems.

Reminder: Throughout the Life Science section, the individual disciplinary core ideas in the boxes only become performance indicators when inserted into the sentence above, in this case replacing the overall topic words, "structures and processes (on a scale from molecules to organisms)." For example with LS1.A.1, it would read, "Students use science and engineering practices, crosscutting concepts, and an understanding that *all organisms have external parts that they use to perform daily functions* to make sense of phenomena and solve problems."

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS1.A: Structure and Function	SCI.LS1.A.1 All organisms have external parts that they use to perform daily functions.	SCI.LS1.A.4 Plants and animals have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.	SCI.LS1.A.m All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.	SCI.LS1.A.h Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism's internal conditions within certain limits and mediate behaviors.
SCI.LS1.B: Growth and Development of Organisms	SCI.LS1.B.1 Parents and offspring often engage in behaviors that help the offspring survive.	SCI.LS1.B.3 Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.	SCI.LS1.B.m Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors.	SCI.LS1.B.h Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.

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Science: Disciplinary Core Ideas (DCI) — Life Science 1 (LS1) – Structures and Processes

Standard SCI.LS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *structures and processes (on a scale from molecules to organisms)* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS1.C: Organization for Matter and Energy Flow in Organisms	SCI.LS1.C.K Animals obtain food they need from plants or other animals. Plants need water and light.	SCI.LS1.A.5 Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter, and obtain energy from sunlight, which is used to maintain conditions necessary for survival.	SCI.LS1.A.m Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.	SCI.LS1.A.h The molecules produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy.
SCI.LS1.D: Information Processing	SCI.LS1.D.1 Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive.	SCI.LS1.D.4 Different sense receptors are specialized for particular kinds of information; animals use their perceptions and memories to guide their actions.	SCI.LS1.D.m Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain resulting in immediate behavior or memories.	SCI.LS1.D.h Organisms can process and store a variety of information through specific chemicals and interconnected networks.

SCI.LS1: Example Three-Dimensional Performance Indicators

Grades K-2	K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive. 1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants or animals use their external parts to help them survive, grow, and meet their needs. 1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.
Grades 3-5	3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles, but all have in common birth, growth, reproduction, and death. 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. 5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.
Grades 6-8	MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells. MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

NOTE: Sample Performance Indicators continued on next page.

SCI.LS1: Example Three-Dimensional Performance Indicators (cont'd)

Grades 9-12	HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and other large carbon-based molecules. HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Science: Disciplinary Core Ideas (DCI) — Life Science 2 (LS2) – Interactions, Energy, and Dynamics within Ecosystems

Standard SCI.LS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *interactions, energy, and dynamics within ecosystems* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS2.A: Interdependent Relationships in Ecosystems	SCI.LS2.A.2 Plants depend on water and light to grow. Plants depend on animals for pollination or to move their seeds around.	SCI.LS2.A.5 The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.	SCI.LS2.A.m Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.	SCI.LS2.A.h Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem. The combination of the factors that affect an organism's success can be measured as a multidimensional niche.

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Science: Disciplinary Core Ideas (DCI) — Life Science 2 (LS2) – Interactions, Energy, and Dynamics within Ecosystems

Standard SCI.LS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *interactions, energy, and dynamics within ecosystems* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS2.B: Cycles of Matter and Energy Transfer in Ecosystems		SCI.LS2.B.5 Matter cycles between the air and soil and among organisms as they live and die.	SCI.LS2.B.m The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.	SCI.LS2.B.h Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in an ecosystem, elements are combined in different ways, and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.

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Science: Disciplinary Core Ideas (DCI) — Life Science 2 (LS2) – Interactions, Energy, and Dynamics within Ecosystems

Standard SCI.LS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *interactions, energy, and dynamics within ecosystems* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS2.C: Ecosystem Dynamics, Functioning, and Resilience		SCI.LS2.C.3 When the environment changes, some organisms survive and reproduce, some move to new locations, some move into transformed environments, and some die.	SCI.LS2.C.m Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.	SCI.LS2.C.h If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.
SCI.LS2.D: Social Interactions and Group Behavior		SCI.LS2.D.3 Being part of a group helps animals obtain food, defend themselves, and cope with changes.	SCI.LS2.D.m Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on -- for example, water purification and recycling.	SCI.LS2.D.h Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

SCI.LS2: Example Three-Dimensional Performance Indicators

Grades K-2 **Grades 3-5**	2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow. 2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. 3-LS2-1. Construct an argument that some animals form groups that help members survive. 5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
Grades 6-8	MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
Grades 9-12	HS-LS2-1. Use mathematical and computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Science: Disciplinary Core Ideas (DCI) — Life Science 3 (LS3) – Heredity

Standard SCI.LS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *heredity* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS3.A: Inheritance of Traits	SCI.LS3.A.1 Young organisms are very much, but not exactly, like their parents, and also resemble other organisms of the same kind.	SCI.LS3.A.3 Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment. Many characteristics involve both inheritance and environment.	SCI.LS3.A.m Genes chiefly regulate a specific protein, which affect an individual's traits.	SCI.LS3.A.h DNA carries instructions for forming species' characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ.
SCI.LS3.B: Variation of Traits	SCI.LS3.B.1 Individuals of the same kind of plant or animal are recognizable as similar, but can also vary in many ways.	SCI.LS3.B.3 Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops.	SCI.LS3.B.m In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.	SCI.LS3.B.h The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

SCI.LS3: Example Three-Dimensional Performance Indicators

Grades K-2	1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.
Grades 3-5	3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. 3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.
Grades 6-8	MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information, and sexual reproduction results in offspring with genetic variation.
Grades 9-12	HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and (3) mutations caused by environmental factors. HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Science: Disciplinary Core Ideas (DCI) — Life Science 4 (LS4) – Biological Evolution

Standard SCI.LS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *biological evolution* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS4.A: Evidence of Common Ancestry and Diversity		SCI.LS4.A.3 Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago.	SCI.LS4.A.m The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent.	SCI.LS4.A.h The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.
SCI.LS4.B: Natural Selection		SCI.LS4.B.3 Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing.	SCI.LS4.B.m Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.	SCI.LS4.B.h Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.

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Science: Disciplinary Core Ideas (DCI) — Life Science 4 (LS4) – Biological Evolution

Standard SCI.LS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *biological evolution* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.LS4.C: Adaptation		SCI.LS4.A.3 Particular organisms can only survive in particular environments.	SCI.LS4.A.m Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.	SCI.LS4.A.h Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence, or extinction, can change when conditions change.
SCI.LS1.D: Biodiversity and Humans	SCI.LS1.D.2 There are many different kinds of living things in any area, and they exist in different places on land and in water.	SCI.LS4.D.3 Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.	SCI.LS4.D.m Changes in biodiversity can influence humans' resources and ecosystem services they rely on.	SCI.LS4.D.h Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

SCI.LS4: Example Three-Dimensional Performance Indicators

Grades K-2	2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.
Grades 3-5	3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. 3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. 3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. 3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
Grades 6-8	MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

NOTE: Sample Performance Indicators continued on next page.

SCI.LS4: Example Three-Dimensional Performance Indicators (cont'd)

Grades 9-12	HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Science: Disciplinary Core Ideas (DCI) — Physical Science 1 (PS1) – Matter and Its Interactions

Standard SCI.PS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *matter and its interactions* to make sense of phenomena and solve problems.

Reminder: Throughout the Physical Science section, the individual disciplinary core ideas in the boxes only become performance indicators when inserted into the sentence above, in this case replacing the overall topic words, "matter and its interactions." For example with PS1.A.2, it would read, "Students use science and engineering practices, crosscutting concepts, and an understanding that *matter exists as different substances that have different observable properties* to make sense of phenomena and solve problems."

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS1.A: Structure and Function	SCI.PS1.A.2 Matter exists as different substances that have different observable properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.	SCI.PS1.A.4 Matter exists as particles that are too small to see. Matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.	SCI.PS1.A.m The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.	SCI.PS1.A.h The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.

NOTE: This standard continued on next page.

Science: Disciplinary Core Ideas (DCI) — Physical Science 1 (PS1) – Matter and Its Interactions

Standard SCI.PS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *matter and its interactions* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS1.B: Chemical Reactions	SCI.PS1.B.2 Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	SCI.PS1.B.5 Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties. In chemical reactions the total mass remains the same. *Note: At this level, students are not expected to differentiate between mass and weight.*	SCI.PS1.B.m Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.	SCI.PS1.B.h Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.
SCI.PS1.C: Nuclear Processes				SCI.PS1.A.h Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy.

SCI.PS1: Example Three-Dimensional Performance Indicators

Grades K-2	2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. 2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. 2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.
Grades 3-5	5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. 5-PS1-3. Make observations and measurements to identify materials based on their properties. 5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
Grades 6-8	MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction, and thus, mass is conserved. MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

NOTE: Sample Performance Indicators continued on next page.

SCI.LS1: Example Three-Dimensional Performance Indicators (cont'd)

Grades 9-12	HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Science: Disciplinary Core Ideas (DCI) — Physical Science 2 (PS2) – Forces, Interactions, Motion, and Stability

Standard SCI.PS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *forces, interactions, motion, and stability* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS2.A: Forces and Motion	SCI.PS2.A.K Pushes and pulls can have different strengths and directions, and can change the speed or direction of an object's motion, or start or stop it. A bigger push or pull makes things speed up or slow down more quickly.	SCI.PS2.A.3 Qualities of motion and changes in motion require description of both size and direction. The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion.	SCI.PS2.A.m Motion and changes in motion can be qualitatively described using concepts of speed, velocity, and acceleration (including speeding up, slowing down, and/or changing direction). The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force (Newton's first and second law). For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law).	SCI.PS2.A.h Motion and changes in motion can be quantitatively described using concepts of speed, velocity, and acceleration (including speeding up, slowing down, and/or changing direction). Newton's second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

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Science: Disciplinary Core Ideas (DCI) — Physical Science 2 (PS2) – Forces, Interactions, Motion, and Stability

Standard SCI.PS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *forces, interactions, motion, and stability* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS2.B: Types of Interactions	SCI.PS2.B.K When objects touch or collide, they push on one another and can result in a change of motion.	SCI.PS2.B.3 Some forces act through contact, some forces (e.g. magnetic, electrostatic) act even when the objects are not in contact. SCI.PS2.B.5 The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	SCI.PS2.B.m Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object.	SCI.PS2.B.h Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields. Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

SCI.PS2: Example Three-Dimensional Performance Indicators

Grades K-2	K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
Grades 3-5	3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. 3-PS2-2. Make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets. 5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.
Grades 6-8	MS-PS2-1. Apply Newton's third law to design a solution to a problem involving the motion of two colliding objects. MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
Grades 9-12	HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS-PS2-2. Use mathematical representations (qualitative and quantitative) to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. HS-PS2-4. Use mathematical representations (qualitative and quantitative) of Newton's law of gravitation and Coulomb's law to describe and predict the gravitational and electrostatic forces between objects. HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Science: Disciplinary Core Ideas (DCI) — Physical Science 3 (PS3) – Energy

Standard SCI.PS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *energy* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS3.A: Definitions of Energy		SCI.PS3.B.4 Moving objects contain energy. The faster the object moves, the more energy it has.	SCI.PS3.A.m Kinetic energy can be distinguished from the various forms of potential energy.	SCI.PS3.A.h Systems move towards more stable states.
SCI.PS3.B: Conservation of Energy and Energy Transfer		SCI.PS3.B.4 Energy can be moved from place to place by moving objects, or through sound, light, or electrical currents. Energy can be converted from one form to another form.	SCI.PS3.A.m Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.	SCI.PS3.A.h The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).
SCI.PS3.C: Relationships between Energy and Forces	SCI.PS3.C.K Bigger pushes and pulls cause bigger changes in an object's motion or shape.	SCI.PS3.C.4 When objects collide, contact forces transfer energy so as to change objects' motions.	SCI.PS3.C.m When two objects interact, each one exerts a force on the other, and these forces can transfer energy between the interacting objects.	SCI.PS3.C.h Fields contain energy that depends on the arrangement of the objects in the field.

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Science: Disciplinary Core Ideas (DCI) — Physical Science 3 (PS3) – Energy

Standard SCI.PS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *energy* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS3.D: Energy in Chemical Processes and Everyday Life	SCI.PS3.D.K Sunlight warms Earth's surface.	SCI.PS3.D.4, 5 Plants capture energy from sunlight which can be used as fuel or food. Stored energy in food or fuel can be converted to useable energy.	SCI.PS3.D.m Sunlight is captured by plants and used in a chemical reaction to produce sugar molecules for storing this energy. This stored energy can be released by respiration or combustion, which can be reversed by burning those molecules to release energy.	SCI.PS3.D.h Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed, but it can be converted to less useful forms.

SCI.PS3: Example Three-Dimensional Performance Indicators

Grades K-2	K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
Grades 3-5	4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. 4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. 4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. 5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.
Grades 6-8	MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object (emphasis on qualitative descriptions of relationships). MS-PS3-2. Develop a model to describe that when the distance between two objects changes, different amounts of potential energy are stored in the system (e.g. gravitational, magnetic or electrostatic potential energy). MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
Grades 9-12	HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Science: Disciplinary Core Ideas (DCI) — Physical Science 4 (PS4) – Waves and their Applications in Technologies for Information Transfer

Standard SCI.PS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *waves and their applications in technologies for information transfer* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS4.A: Wave Properties	SCI.PS4.A.1 Sound can make matter vibrate, and vibrating matter can make sound.	SCI.PS4.A.4 Waves are regular patterns of motion, which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move.	SCI.PS4.C.m A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy.	SCI.PS4.A.h The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.
SCI.PS4.B: Electro-magnetic Radiation	SCI.PS4.B.1 Objects can be seen only when light is available to illuminate them.	SCI.PS4.B.4 Objects can be seen when light reflected from their surface enters our eyes.	SCI.PS4.B.m The construct of a wave is used to model how light interacts with objects.	SCI.PS4.B.h Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.

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Science: Disciplinary Core Ideas (DCI) — Physical Science 4 (PS4) – Waves and their Applications in Technologies for Information Transfer

Standard SCI.PS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *waves and their applications in technologies for information transfer* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.PS4.C: Information Technologies and Instru-mentation	SCI.PS4.C.1 People use devices to send and receive information.	SCI.PS4.C.4 Patterns can encode, send, receive, and decode information.	SCI.PS4.C.m Waves can be used to transmit digital information. Digitized information is comprised of a pattern of 1s and 0s.	SCI.PS4.C.h Large amounts of information can be stored and shipped around as a result of being digitized.

SCI.PS4: Example Three-Dimensional Performance Indicators

Grades K-2	1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. 1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated. 1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. 1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.
Grades 3-5	4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. 4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. 4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.
Grades 6-8	MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
Grades 9-12	HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 1 (ESS1) – Earth's Place in the Universe

Standard SCI.ESS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth's place in the universe* to make sense of phenomena and solve problems.

Reminder: Throughout the Earth and Space Science section, the individual disciplinary core ideas in the boxes only become performance indicators when inserted into the sentence above, in this case replacing the overall topic words, "Earth's place in the universe." For example with ESS1.A.1, it would read, "Students use science and engineering practices, crosscutting concepts, and an understanding that *patterns of movement of the sun, moon, and stars, as seen from the Earth, can be observed, described and predicted* to make sense of phenomena and solve problems."

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS1.A: The Universe and Its Stars	SCI.ESS1.A.1 Patterns of movement of the sun, moon, and stars, as seen from Earth, can be observed, described, and predicted.	SCI.ESS1.A.5 Stars range greatly in size and distance from Earth, and this can explain their relative brightness.	SCI.ESS1.A.m The solar system is part of the Milky Way, which is one of many billions of galaxies.	SCI.ESS1.A.h Light spectra from stars are used to determine their characteristics, processes, and lifecycles. Solar activity creates the elements through nuclear fusion. The development of technologies has provided the astronomical data that provide the empirical evidence for the Big Bang theory.

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Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 1 (ESS1) – Earth's Place in the Universe

Standard SCI.ESS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth's place in the universe* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS1.B: Earth and the Solar System	SCI.ESS1.B.1 Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	SCI.ESS1.B.5 The Earth's orbit and rotation, and the orbit of the moon around the Earth cause observable patterns.	SCI.ESS1.B.m The solar system contains many varied objects held together by gravity. Solar system models explain and predict eclipses, lunar phases, and seasons.	SCI.ESS1.B.h Kepler's laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. Cyclical changes in Earth's tilt and orbit, occurring over tens to hundreds of thousands of years, cause cycles of ice ages and other gradual climate changes.
SCI.ESS1.C: The History of Planet Earth	SCI.ESS1.C.2 Some events on Earth occur very quickly; others can occur very slowly.	SCI.ESS1.C.4 Certain features on Earth can be used to order events that have occurred in a landscape.	SCI.ESS1.C.m Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.	SCI.ESS1.C.h The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations.

SCI.ESS1: Example Three-Dimensional Performance Indicators

Grades K-2	1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted. 1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year. 2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.
Grades 3-5	4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. 5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth. 5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
Grades 6-8	MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
Grades 9-12	HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 2 (ESS2) – Earth's Systems

Standard SCI.ESS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth's systems* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS2.A: Earth Materials and Systems	SCI.ESS2.A.2 Wind and water change the shape of the land.	SCI.ESS2.A.4.5 Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around.	SCI.ESS2.A.m Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.	SCI.ESS2.A.h Feedback effects exist within and among Earth's systems.
SCI.ESS2.B: Plate Tectonics and Large-Scale System Interactions	SCI.ESS2.B.2 Maps show where things are located. One can map the shapes and kinds of land and water in any area.	SCI.ESS2.B.4 Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events.	SCI.ESS2.B.m Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history. Maps are used to display evidence of plate movement.	SCI.ESS2.B.h Radioactive decay within Earth's interior contributes to thermal convection in the mantle.

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Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 2 (ESS2) – Earth's Systems

Standard SCI.ESS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth's systems* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS2.C: The Roles of Water in Earth's Surface Processes	SCI.ESS2.C.2 Water is found in many types of places and in different forms on Earth.	SCI.ESS2.C.5 Most of Earth's water is in the ocean, and much of the Earth's freshwater is in glaciers or underground.	SCI.ESS2.C.m Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.	SCI.ESS2.C.h The planet's dynamics are greatly influenced by water's unique chemical and physical properties.
SCI.ESS2.D: Weather and Climate	SCI.ESS2.D.K Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region and time. People record weather patterns over time.	SCI.ESS2.D.3 Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed.	SCI.ESS2.D.m Complex interactions determine local weather patterns and influence climate, including the role of the ocean.	SCI.ESS2.D.h The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

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Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 2 (ESS2) – Earth's Systems

Standard SCI.ESS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth's systems* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

SCI.ESS2.E: Biogeology	SCI.ESS2.E.K Plantsand animals can change their local environment.	SCI.ESS2.E.4 Living things can affect the physical characteristics of their environment.	SCI.ESS2.E.m The fossil record documents the existence, diversity, extinction, and change of many life forms throughout history (linked to content in LS4.A).	SCI.ESS2.E.h The biosphere and Earth's other systems have many interconnections that cause a continual coevolution of Earth's surface and life on it.

SCI.ESS2: Example Three-Dimensional Performance Indicators

Grades K-2	K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. 2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. 2-ESS2-3. Obtain information to identify where water is found on Earth, and that it can be solid or liquid.
Grades 3-5	3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. 3-ESS2-2. Obtain and combine information to describe climates in different regions of the world. 4-ESS2-1. Make observations and measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. 4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and atmosphere interact. 5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
Grades 6-8	MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives plate tectonics. MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

NOTE: Sample Performance Indicators continued on next page.

SCI.ESS2: Example Three-Dimensional Performance Indicators (cont'd)

Grades 9-12	HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems. HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 3 (ESS3) – Earth and Human Activity

Standard SCI.ESS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth and human activity* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS3.A: Natural Resources	SCI.ESS3.A.K Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	SCI.ESS3.A.4 Energy and fuels humans use are derived from natural sources, and their use affects the environment. Some resources are renewable over time, others are not.	SCI.ESS3.A.m Humans depend on Earth's land, oceans, fresh water, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.	SCI.ESS3.A.h Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.
SCI.ESS3.B: Natural Hazards	SCI.ESS3.B.K In a region, some kinds of severe weather are more likely than others. Forecasts allow communities to prepare for severe weather.	SCI.ESS3.B.3,4 A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.	SCI.ESS3.B.m Patterns can be seen through mapping the history of natural hazards in a region and understanding related geological forces.	SCI.ESS3.B.h Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.

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Science: Disciplinary Core Ideas (DCI) — Earth and Space Science 3 (ESS3) – Earth and Human Activity

Standard SCI.ESS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *earth and human activity* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ESS3.C: Human Impacts on Earth Systems	SCI.ESS3.C.K Things people do can affect the environment but they can make choices to reduce their impacts.	SCI.ESS3.C.5 Societal activities have had major effects on the land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.	SCI.ESS3.C.m Human activities have altered the hydrosphere, atmosphere, and lithosphere which in turn has altered the biosphere. Changes to the biosphere can have different impacts for different living things. Activities and technologies can be engineered to reduce people's impacts on Earth.	SCI.ESS3.C.h Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.
SCI.ESS3.D: Global Climate Change			SCI.ESS3.D.m Evidence suggests human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.	SCI.ESS3.D.h Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.

SCI.ESS3: Example Three-Dimensional Performance Indicators

Grades K-2	K-ESS3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, or other living things in the local environment.
Grades 3-5	3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
Grades 6-8	MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

NOTE: Sample Performance Indicators continued on next page.

SCI.ESS3: Example Three-Dimensional Performance Indicators (cont'd)

Grades 9-12	HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 1 (ETS) – Engineering Design

Standard SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *engineering design* to make sense of phenomena and solve problems.

Reminder: Throughout the Engineering, Technology, and the Application of Science section, the individual disciplinary core ideas in the boxes only become performance indicators when inserted into the sentence above, in this case replacing the overall topic words, "engineering design." For example with ETS1.A.K-2, it would read, "Students use science and engineering practices, crosscutting concepts, and an understanding that *a situation that people want to change or create can be approached as a problem to solved through engineering* to make sense of phenomena and solve problems." Additionally, these engineering ideas are meant to be integrated with related science learning, not taught in isolation.

Performance Indicators (by Grade Band)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS1.A: Defining and Delimiting Engineering Problems	SCI.ETS1.A.K-2 A situation that people want to change or create can be approached as a problem to be solved through engineering. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.	SCI.ETS1.A.3-5 Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	SCI.ETS1.A.m The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	SCI.ETS1.A.h Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 1 (ETS1) – Engineering Design

Standard SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *engineering design* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS1.A: Defining and Delimiting Engineering Problems (cont'd)				SCI.ETS1.A.h Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.
SCI.ETS1.B: Developing Possible Solutions	SCI.ETS1.B.K-2 Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	SCI.ETS1.B.3-5 Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.	SCI.ETS1.C.m A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	SCI.ETS1.C.h When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 1 (ETS1) – Engineering Design

Standard SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *engineering design* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS1.B: Developing Possible Solutions (cont'd)		SCI.ETS1.B.3-5 At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.	SCI.ETS1.C.m Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions.	SCI.ETS1.C.h Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical. They are also useful in making a persuasive presentation to a client about how a given design will meet his or her needs.
SCI.ETS1.C: Optimizing the Design Solution	SCI.ESS1.C.2 Because there is more than one possible solution to a problem, it is useful to compare and test designs.	SCI.ESS1.C.4 Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	SCI.ESS1.C.m Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—	SCI.ESS1.C.h Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 1 (ETS1) – Engineering Design

Standard SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *engineering design* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS1.C: Optimizing the Design Solution (cont'd)			SCI.ESS1.C.m That is, some of those characteristics may be incorporated into the new design. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

SCI.ETS1: Example Three-Dimensional Performance Indicators

Grades K-2	K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
Grades 3-5	3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. 3-5-ETS1-2. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
Grades 6-8	MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success. MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
Grades 9-12	HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 2 (ETS2) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *links among engineering, technology, science, and society* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS2.A: Interdepen-dence of Science, Engineering, and Technology	SCI.ETS2.A.K-2 Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	SCI.ETS2.A.3-5 Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions.	SCI.ETS2.A.m A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	SCI.ETS2.A.h When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
SCI.ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World	SCI.ETS2.B.K-2 Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. Taking natural materials to make things impacts the environment.	SCI.ETS2.B.3-5 People's needs and wants change over time, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.	SCI.ETS2.B.m All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.	SCI.ETS2.B.h Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 2 (ETS2) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *links among engineering, technology, science, and society* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World (cont'd)		SCI.ETS2.B.3-5 When new technologies become available, they can bring about changes in the way people live and interact with one another.	SCI.ETS2.B.m The uses of technologies are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Technology use varies over time and from region to region.	SCI.ETS2.B.h Engineers continuously modify these systems to increase benefits while decreasing costs and risks. New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

SCI.ETS2: Example Three-Dimensional Performance Indicators

Grades K-2	K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, or other living things in the local environment. 1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants or animals use their external parts to help them survive, grow, and meet their needs.
Grades 3-5	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
Grades 6-8	MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
Grades 9-12	HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 3 (ETS3) – Nature of Science and Engineering

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the *nature of science and engineering* to make sense of phenomena and solve problems.

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS3.A: Science and Engineering Are Human Endeavors	SCI.ETS3.A.K-2 People of diverse backgrounds can become scientists and engineers. People have practiced science and engineering for a long time. Creativity and imagination are important to science and engineering.	SCI.ETS3.A.3-5 Science and engineering knowledge have been created by many cultures. People use the tools and practices of science and engineering in many different situations (e.g. land managers, technicians, nurses and welders). Science and engineering affect everyday life.	SCI.ETS3.A.m Individuals and teams from many nations, cultures and backgrounds have contributed to advances in science and engineering. Scientists and engineers are persistent, use creativity, reasoning, and skepticism, and remain open to new ideas. Science and engineering are influenced by what is valued in society.	SCI.ETS3.A.h Individuals from diverse backgrounds bring unique perspectives that are valuable to the outcomes and processes of science and engineering. Scientists' and engineers' backgrounds, perspectives, and fields of endeavor influence the nature of questions they ask, the definition of problems, and the nature of their findings and solutions. Some cultures have historically been marginalized in science and engineering discourse.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 3 (ETS3) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the *nature of science and engineering* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS3.A: Science and Engineering Are Human Endeavors (cont'd)				SCI.ETS3.A.h Scientists and engineers embrace skepticism and critique as a community. Deliberate deceit in science is rare and is likely exposed through the peer review process. When discovered, intellectual dishonesty is condemned by the scientific community.
SCI.ETS3.B: Science and Engineering Are Unique Ways of Thinking with Different Purposes	SCI.ETS3.B.K-2 Scientists use evidence to explain the natural world. Science assumes natural events happen today as they happened in the past. Engineers solve problems to meet the needs of people and communities.	SCI.ETS3.B.3-5 Science and engineering are both bodies of knowledge and processes that add new knowledge to our understanding. Scientific findings are limited to what can be supported with evidence from the natural world.	SCI.ETS3.B.m Science asks questions to understand the natural world and assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Science carefully considers and evaluates anomalies in data and evidence.	SCI.ETS3.B.h Science is both a body of knowledge that represents current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge. These processes differentiate science from other ways of knowing.

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Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 3 (ETS3) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the *nature of science and engineering* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS3.B: Science and Engineering Are Unique Ways of Thinking with Different Purposes (cont'd)		SCI.ETS3.B.3-5 Basic laws of nature are the same everywhere in the universe (e.g. gravity, conservation of matter, energy transfer, etc.). Engineering solutions often have drawbacks as well as benefits.	SCI.ETS3.B.m Engineering seeks solutions to human problems, including issues that arise due to human interaction with the environment. It uses some of the same practices as science and often applies scientific principles to solutions. Science and engineering have direct impacts on the quality of life for all people. Therefore, scientists and engineers need to pursue their work in an ethical manner that requires honesty, fairness and dedication to public health, safety and welfare.	SCI.ETS3.B.h Science knowledge has a history that includes the refinement of, and changes to, theories, ideas and beliefs over time. Science and engineering innovations may raise ethical issues for which science and engineering, by themselves, do not provide answers and solutions.

Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 3 (ETS3) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the *nature of science and engineering* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS3.C: Science and Engineering Use Multiple Approaches to Create New Knowledge and Solve Problems	SCI.ETS3.C.K-2 Science and engineers use many approaches to answer questions about the natural world and solve problems. Scientific explanations are strengthened by being supported with evidence. An engineering problem can have many solutions. The strength of a solution depends on how well it solves the problem.	SCI.ETS3.C.3-5 The products of science and engineering are not developed through one set "scientific method" or "engineering design process." Instead, they use a variety of approaches described in the Science and Engineering Practices. Science explanations are based on a body of evidence and multiple tests, and describe the mechanisms for natural events. Science explanations can change based on new evidence. There is no perfect design in engineering. Designs that are best in some ways (e.g. safety or ease of use) may be inferior in other ways (e.g. cost or aesthetics).	SCI.ETS3.C.m A theory is an explanation of some aspect of the natural world. Scientists develop theories by using multiple approaches. Validity of these theories and explanations is increased through a peer review process that tests and evaluates the evidence supporting scientific claims. Theories are explanations for observable phenomena based on a body of evidence developed over time. A hypothesis is a statement that can be tested to evaluate a theory. Scientific laws describe cause and effect relationships among observable phenomena.	SCI.ETS3.C.h Scientists use a variety of methods, tools and techniques to develop theories. A scientific theory is an explanation of some aspect of the natural word, based on evidence that has been repeatedly confirmed through observation, experimentation (hypothesis-testing), and peer review. The certainty and durability of science findings varies based on the strength of supporting evidence. Theories are usually modified if they are not able to accommodate new evidence.

Science: Disciplinary Core Ideas (DCI) — Engineering, Technology, and the Application of Science 3 (ETS3) – Links among Engineering, Technology, Science, and Society

Standard SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the *nature of science and engineering* to make sense of phenomena and solve problems. (cont'd)

Performance Indicators (by Grade in K-5, Grade Band in 6-12)

Learning Priority	K-2	3-5	6-8 (m)	9-12 (h)
SCI.ETS3.C: Science and Engineering Use Multiple Approaches to Create New Knowledge and Solve Problems (cont'd)			SCI.ETS3.C.m Engineers develop solutions using multiple approaches and evaluate their solutions against criteria such as cost, safety, time and performance. This evaluation often involves trade-offs between constraints to find the optimal solution.	SCI.ETS3.C.h Engineers use a variety of approaches, tools, and techniques to define problems and develop solutions to those problems. Successful engineering solutions meet stakeholder needs and safety requirements, and are economically viable. Trade-offs in design aspects balance competing demands.

SCI.ETS3: Example Three-Dimensional Performance Indicators

Grades K-2	K-ETS3-1. Compare data from two types of investigations (e.g. hands-on and computer-based games) to show that pushes and pulls of different strengths have different effects (PS2.A.K). 1-ETS3-1. Construct an argument with evidence that humans today and long ago have used ideas from plants and animals to help them survive (LS1.A.1). 2-ETS3-1. Design creative solutions to a problem caused when there is a quick change to the earth's surface (e.g. natural disasters) (ESS1.C.2).
Grades 3-5	3-ETS3-1. Obtain and evaluate information showing that different cultures have created different tools and technologies to survive in different types of environments (LS2.C.3). 4-ETS3-1. Construct an explanation for how energy is transferred in a system, and then revise that explanation based on new evidence (PS3.B.4). 5-ETS3-1. Investigate properties of materials to provide evidence as to which would best work within an engineering design solution (PS1.A.5).
Grades 6-8	MS-ETS3-1. Construct an argument supported by evidence about the values held by different societies based on the resources expended for exploration and understanding of the universe (ESS1.B.m). MS-ETS3-2. Evaluate information and evidence about issues related to genetically modifying organisms and identify questions that can, and cannot, be answered by science (LS3.B.m). MS-ETS3-3. Mathematically evaluate products of chemical and physical changes to support ideas of atomic theory (PS1.A.m).
Grades 9-12	HS-ETS3-1. Ask questions to clarify an author's motivation for promoting unscientific or falsified information on science topics (e.g. climate change, vaccines, GMOs, nuclear energy) (SEP.1.h). HS-ETS3-2. Create simulations of antibiotic resistance, showing how varying use of antibiotics over time has affected evolution of bacteria, and reflecting on how an understanding of the pros and cons of antibiotic use has changed over time (LS4.C.h). HS-ETS3-3. Provide evidence that multiple approaches to understanding climate change have resulted in stronger theories of why change happens over time (ESS3.D.h).

Section IV

Disciplinary Literacy: Literacy for Learning in Science

What is Disciplinary Literacy?

Scientists and engineers have unique ways of accessing and communicating information through specialized language and text specific to science and within the various disciplines of science and engineering. Students benefit from educators who understand science and engineering practices in order to link language skills to this complex content. Disciplinary literacy in science focuses on the unique ways that scientists and engineers interact with texts such as data sheets and journal articles.

In Wisconsin, disciplinary literacy is defined as the confluence of content knowledge, experiences, and skills merged with the ability to read, write, listen, speak, think critically, and perform in a way that is meaningful within the context of a given field.

Scientists and other STEM professionals have unique ways of accessing and communicating information. Students generally do not gain those skills in an English course. They benefit from explicit instruction by someone who understands scientific practices in order to link language skills to this complex content. For example, having students read a text and identify main points and key vocabulary *is not* disciplinary literacy; disciplinary literacy in science focuses on the unique ways that scientists interact with texts.

The *Wisconsin Academic Standards for Literacy in All Subjects* are connected to each set of content-specific standards to guide educators as they strive to help students meet the literacy challenges within each particular field of study. This national effort is referred to as disciplinary literacy.

Disciplinary literacy is important in ALL courses and subjects at all grade levels. Therefore, the *Wisconsin Academic Standards for Literacy in All Subjects* provide standards for cross-discipline literacy in **all disciplines and every grade level K-12.** This literacy focus must begin as soon as children have access to formal education and continue intentionally as college and career readiness goals advance for all children in Wisconsin.

Elementary classroom teachers build the foundational literacy skills necessary for students to access all learning. Additionally, they develop content-specific literacy skills to read, write, listen, speak, and think critically in each discipline beginning at an early age. The applicable K-5 standards help educators in Wisconsin build a ladder of skills and dispositions that lead to accelerated achievement across disciplines.

Why is Disciplinary Literacy Important?

The modern global society, of which our students are a part, requires postsecondary learning. An analysis of workforce trends by Georgetown University economist Anthony Carnevale and his colleagues found that likely 65 percent of all job openings in 2020

will require some postsecondary education. Postsecondary success depends on students' ability to comprehend and produce the kinds of complex texts found in all disciplines. Therefore, the economic future of our state, as well as our students and their success as productive citizens and critical thinkers, links to disciplinary literacy.

Textbooks, articles, manuals, and primary source documents create specialized challenges for learners. These texts often include abstracts, figures, tables, diagrams, and specialized vocabulary. The ideas are complex and build across a number of paragraphs requiring focus and strategic processing. To comprehend and produce this type of text, students must be immersed in the language and thinking processes of science, and they must be supported by an expert guide, their teacher (Carnegie Report, 2010).

Literacy is Critical—— *Literacy is integral to attainment of science content knowledge and science content is essential background knowledge for literacy development. This interdependent relationship exists in all disciplines.*

A focus at the elementary level on foundational reading, when expanded to include engaging experiences connected to informational texts, vocabulary, and writing for content-specific purposes, builds background knowledge and skills in each discipline. This increases opportunities for success as students approach more rigorous content in those disciplines (Alliance for Excellent Education, 2011). Notably, reading and writing *about* science, which are most often only literacy experiences, cannot substitute for hands-on experiences in science investigation, which is critical from K through 12, not only secondary courses.

Reading, writing, speaking, listening, and critical thinking must be integrated into each discipline across all grades so that all students gradually build knowledge and skills toward college and career readiness. Collaboration among institutes of higher education, CESA Statewide Network, districts, schools, teachers, and family and community will guide the implementation of the standards in Wisconsin.

All Wisconsin standards require educators to support literacy in each classroom across the state. In science that specifically relates to learning the disciplinary literacy of scientists and engineers, not general literacy instruction such as grammar or reading comprehension. Since the impact of this disciplinary literacy effort is significant, it is essential that resources and supports be accessible to all educators. To build consistent understanding, DPI convened a statewide Disciplinary Literacy Leadership Team in 2011 comprised of educators from many content areas and educational backgrounds. This team was charged with examining standards, identifying the needs in the field for support, and gathering materials and resources to address those needs.

Wisconsin Foundations for Disciplinary Literacy

To guide understanding and professional learning, a set of foundations, developed in concert with Wisconsin's *Guiding Principles for Teaching and Learning*, directs Wisconsin's approach to disciplinary literacy.

The literacy skills of reading, writing, listening, speaking, and critical thinking improve when content-rich learning experiences motivate and engage students.

Our goals for Wisconsin students are:

1. Demonstrate independence.
2. Build strong content and knowledge.
3. Respond to the varying demands of audience, task, purpose and discipline.
4. Comprehend as well as critique.
5. Value evidence.
6. Use technology and digital media strategically and capably.
7. Come to understand other perspectives and cultures.

Academic learning begins in early childhood and develops across all disciplines.

Each discipline has its own specific vocabulary, text types, and ways of communicating. Children begin learning these context- and content-specific differences early in life and continue through high school and beyond. While gardening, small children observe the form and function of a root, stem, leaf, and soil; or measure, mix, and blend while baking a cake. School offers all students opportunities to develop the ability to, for example, think like a scientist, write like a historian, critique like an artist, problem solve like an engineer, or analyze technological advances like a health care technician. As literacy skills develop, educators gradually shift the responsibility for reading, writing, listening, speaking, and critical thinking to students through guided supports in both individual and collaborative learning experiences.

Content knowledge is strengthened when educators integrate discipline-specific literacy into teaching and learning.

Educators help students recognize and understand the nuances of a discipline by using strategies that "make their thinking visible." They promote classroom reading, writing, listening, speaking, and critical thinking using authentic materials that support the development of content-specific knowledge. They guide students through these complex texts by using strategies that

develop conceptual understanding of language and set expectations for relevant application of skills. These literacy practices deepen students' content knowledge, strategies, and skills so that their learning transfers to real-world situations.

> *"The ability to comprehend written texts is not a static or fixed ability, but rather one that involves a dynamic relationship between the demands of texts and prior knowledge and goals of the reader."*

Educators who foster disciplinary literacy develop experiences that integrate rigorous content with relevant collaborative and creative literacy processes to motivate and engage students. Setting high expectations, they structure routines and supports that empower students to take charge of their own learning. When students work in teams to research science and mathematics concepts in the development of an invention, or a graphic arts design or when they collaboratively build a blog that contains their recent marketing venture, they use specific literacy skills and strategies to solidify learning. Students need these opportunities over time to develop the precise and complex reading, writing, listening, speaking, and critical thinking skills demanded in today's careers.

Students demonstrate their content knowledge through reading, writing, listening, and speaking as part of a content-literate community.

Students who are literate in a particular discipline are able to successfully read, write, and speak about that discipline and can listen to and think critically as others communicate in that community. Performance tasks that allow students to present the complexity of a content area in a way that is meaningful to the field become authentic approaches to assessing mastery within a discipline. Such tasks empower students to discover the real-world connections across disciplines and to actively participate in communities of discipline-literate peers.

What research and resources are available?

The *Wisconsin Academic Standards for Literacy in All Subjects* reflect the importance of literacy in both the oral and written language and in both productive (speaking and writing) and receptive (listening and reading) discourse. Clearly, critical and precise thinking are required to develop all of these specific strategies and skills. The standards also address the learning and functioning of language in a technological, media-driven world because the language that we use is selective depending upon the context of the conversation.

The following section offers relevant research and resources to support professional learning in reading, writing, speaking, listening, and language across disciplines. Collegial conversation and learning, both cross-discipline and within-discipline, will help make the Wisconsin Academic Standards more applicable to schools and districts and will address the needs of unique programs within those contexts. A collection of online resources will continue to develop as support materials emerge.

Reading Connections

While early reading focuses on learning that letters make sounds and that words carry meaning, reading quickly develops to a point where the message taken from text depends on what the reader brings to it. *The Carnegie Report, Reading in the Disciplines* (2010), describes this phenomenon:

> Therefore, a musician reading a journal article that describes concepts in music theory will take more information away from the text than a music novice because of their knowledge and experience in music. As well, an individual who spends a significant amount of time reading automotive manuals will more easily navigate a cell phone manual because of familiarity with that type of text.

A chart excerpted from the Carnegie Report (2010) details a few of the generic and more discipline-specific strategies that support students as they attempt to comprehend complex text. While the generic strategies pertain across content areas, discipline-specific ones must be tailored to match the demands of the content area.

Both generic and discipline focused strategies and knowledge must be applied to the comprehension and evaluation of:

- textbooks
- journal and magazine articles
- historically situated primary documents
- full-length books
- newspaper articles
- book chapters
- multimedia and Digital Texts

Generic reading strategies*

- Monitoring comprehension
- Pre-reading
- Setting goals

- Thinking about what one already knows
- Asking questions
- Making predictions
- Testing predictions against the text
- Re-reading
- Summarizing

Discipline-specific reading strategies*

- Building prior knowledge
- Building specialized vocabulary
- Learning to deconstruct complex sentences
- Using knowledge of text structures and genres to predict main and subordinate ideas
- Mapping graphic (and mathematical) representations against explanations in the text
- Posing discipline-relevant questions
- Comparing claims and propositions across texts
- Using norms for reasoning within the discipline (i.e. what counts as evidence) to evaluate claims

*Source: Carnegie Report, (2010)

Additional resources support reading in specific subjects. *Content Counts! Developing Disciplinary Literacy Skills, K–6* by Jennifer L. Altieri (2011) is a guide for discipline-specific literacy at the elementary level and offers strategies to balance the demands of literacy while continuing to make content count and help students meet the reading, writing, speaking and listening demands of the content areas as they advance in school.

A resource by Doug Buehl (2011), *Developing Readers in the Academic Disciplines*, describes what it means to read, write, and think through a disciplinary lens in the adolescent years. This teacher-friendly guide helps connect literacy with disciplinary understandings to bridge academic knowledge gaps, frontload instruction, and build critical thinking through questioning.

Note on range and content of student reading

The *Wisconsin Academic Standards for Literacy in All Subjects* require that "students must read widely and deeply from among a broad range of high-quality, increasingly challenging...text." This type of reading—included in an intentionally developed curriculum—supports students in building a base of content-specific knowledge while developing skills to read increasingly complex text.

Writing Next: Effective Strategies to Improve Writing of Adolescents in Middle and High Schools (2007), detailed research on writing to learn, rather than only for assessment, as having a significant impact on content learning.

Wisconsin uses a three-part model for text complexity, considering qualitative, quantitative, and reader-and-task demands (see https://dpi.wi.gov/reading/professional-learning/text-complexity for more information). In addition, a well-developed collection of complex texts carefully considers representation and diversity, including diversity in the creators and topics of texts.

Writing Connections

The *Wisconsin Academic Standards for Literacy in All Subjects* call for emphasis on three types of writing: narrative, informational, and argument. Writing that presents a logical argument is especially appropriate to discipline-specific work since credible evidence differs across content areas. The ability to consider multiple perspectives, assess the validity of claims, and present a point of view is required in argumentative writing. These thinking and communication skills are "critical to college and career readiness."

The study found writing to learn was equally effective for all content areas in the study (social studies, math, and science) and at every grade (4-12).

Note on range and content of student writing

The *Wisconsin Academic Standards for Literacy in All Subjects* require that students "write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences." This breadth and depth of writing ensures students are able to flexibly select a format to meet the needs of a specific audience and purpose. This is accomplished through significant amounts of time dedicated to varied writing.

Speaking, Listening, and Language Connections

The ability to share ideas and orally communicate with credibility in a specific academic discourse empowers students and allows access to specialized groups. In Situated Language and Learning: A Critique of Traditional Schooling, James Paul Gee (2004) describes the need to prioritize these skills so that students are at ease as they enter situations connected to a specific content area and are more likely to continue their learning in that discipline.

Students must have extensive vocabularies, built through reading and explicit instruction embedded in the context of content learning. This enables them to comprehend complex texts, engage in purposeful writing and communicate effectively within a discipline.

As expertise develops, students feel more and more comfortable applying knowledge and skills while speaking and listening in a specific discipline.

- A media course may teach students appropriate expression, tone, and rate of speech when addressing a large audience.
- Listening carefully to questions posed is a specialized skill that debate facilitators develop.
- Scientists learn to listen for bias in the perspectives presented by peers to determine the reliability of scientific outcomes.
- Artists have very specialized and specific ways of speaking about the many aspects of a piece.

A policy brief from the Alliance for Excellent Education, *Engineering Solutions to the National Crisis in Literacy* describes "a staircase of literacy demands" and emphasizes the importance of a progressive development of language and literacy over time.

The conceptual understanding of "functions" in mathematics may begin to develop in elementary school in its simplest form. As the concept develops over the years, students will use the word "function" in a meaningful way when speaking and writing to describe the mathematical concept they apply. When educators explicitly connect a mathematical term to its application and repeatedly expose students to the concept connected to the term, a specialized language becomes second nature to the mathematics classroom.

Skills in determining or clarifying the meaning of words and phrases encountered, choosing flexibly from an array of strategies, and seeing an individual word as part of a network of other words that, for example, have similar denotations but different connotations, allow students to access information and support their own learning.

Literacy in Multiple Languages

Increasing economic, security, cross-cultural, and global demands underscore the value of literacy in more than one language. Students who think, read, write, and communicate in multiple languages are an asset to our own country and can more easily interact and compete in the world at large.

English learners in our classrooms face significant challenges as they add a new language and work to grasp content at the same rate as their English-speaking peers. In a report to the Carnegie Corporation, *Double the Work: Challenges and Solutions to Acquiring Academic Literacy for Adolescent English Language Learners (2007)*, researchers found that a focus on academic literacy is crucial for English language learners' success in school. In their description of academic literacy, they include reading, writing, and oral discourse that:

- varies from subject to subject;
- requires knowledge of multiple genres of text, purposes for text use, and text media;
- is influenced by students' literacies in context outside of school; and
- is influenced by students' personal, social, and cultural experiences.

The needs of our English learners are addressed when we embed disciplinary literacy strategies into our subject area teaching. These high impact strategies and skills allow English language learners and all students to more readily access content knowledge and connect it to the prior knowledge they bring to the classroom. When educators take the initiative to understand and embed these strategies and skills, they offer additional opportunities for success to all of our students.

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