



## Frequently Asked Questions

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### Purpose of Next Generation Science Standards

#### **Why new science standards? Why now?**

Science—and therefore science education—is central to the lives of all Americans, preparing them to be informed citizens in a democracy and knowledgeable consumers. It is also the case that if the nation is to compete and lead in the global economy and if American students are to be able to pursue expanding employment opportunities in science-related fields, all students must all have a solid K–12 science education that prepares them for college and careers. States have previously used the National Science Education Standards from the National Research Council (NRC) and Benchmarks for Science Literacy from the American Association for the Advancement of Science (AAAS) to guide the development of their current state science standards. While these two documents have proven to be both durable and of high quality, they are around 15 years old. Needless to say, major advances have since taken place in the world of science and in our

understanding of how students learn science effectively. The time is right to take a fresh look and develop Next Generation Science Standards.

### **Contents and Research Background of the Standards**

**How will critical thinking and communications skills, which are fundamental to student success in today's global economy, be addressed in the Next Generation Science Standards?**

It is important to understand that the scientific practices defined by the NRC include the critical thinking and communication skills that students need for postsecondary success and citizenship in a world fueled by innovations in science and technology. These science practices encompass the habits and skills that scientists and engineers use day in and day out. In the Next Generation Science Standards these practices will be wedded to content. In other words, content and practice will be intertwined in the standards, just as they are in the NRC Framework and in today's workplace.

**How will the standards take into account current research in cognitive science?**

Research on how students learn science effectively has been a long-term interest of the National Research Council, which published *How People Learn*, *How Students Learn*, and most recently, *Taking Science to School*. Findings in cognitive science permeate the Framework for K–12 Science Education and will be central to developing the Next Generation Science Standards.

**Will the standards be internationally benchmarked?**

Yes. Achieve undertook a study of 10 countries' standards to determine their overall emphases in the expectations they have for all students (grade spans 1–6 and 7–10), as well as emphases in Biology, Chemistry, Physics and Earth/Space courses in upper secondary. The comparison countries were generally those whose students performed well on the Programme for International Student Assessment (PISA) or the Trends in International Math and Science Study (TIMSS): Ontario Canada, Chinese Taipei, England, Finland, Hong Kong, Hungary, Ireland, Japan, Singapore and South Korea. Achieve's study consisted of two parts: a quantitative analysis of the knowledge and performances included in each country's standards; and a qualitative in-depth review of five of the ten countries that offered the most guidance for constructing useful and meaningful standards.

The quantitative analysis enabled Achieve to detect patterns of emphases in major categories of knowledge and performances. Major findings for grade span 1–10 were as follows: Seven of 10 countries require general science for all students through grade 10, prior to students taking discipline-specific courses; Physical science (chemistry and physics taken together) receives the most attention; Biology receives somewhat less attention, and Earth/space science much less; Crosscutting content, such as the nature of science and engineering, and the interactions of science, technology and society, and environmental sustainability also receives significant attention. Achieve's qualitative analysis revealed exemplary features that we hope to incorporate in the Next Generation Science Standards, such as: the use of an overarching conceptual framework; multiple examples to clarify the level of rigor expected and connect concepts with applications; concrete links between standards and assessments; and development of inquiry and design processes in parallel to facilitate students engaging in both science and engineering practices. (Additional information regarding the study can be found at [www.Achieve.org](http://www.Achieve.org).)

### **What are core ideas in science?**

The NRC defines disciplinary core ideas as those that focus K–12 science curriculum, instruction and assessments on the most important aspects of science disciplinary content knowledge. In order to identify the relevant core ideas for K–12 level science, the NRC Framework Committee developed and applied a set of criteria. To be considered "core", the ideas should meet at least two of the following criteria and ideally all four: Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline; Provide a key tool for understanding or investigating more complex ideas and solving problems; Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge; Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. Design teams working in four domains – life sciences, physical sciences, earth and space sciences, and engineering and technology – supported the work of the committee on core ideas, examining related research and key documents. These included recent research on teaching and learning science, much of which has been summarized in previous reports from the NRC—How People Learn, Taking Science to School, Learning Science in Informal Environments, Systems for State Science Assessment and America's Lab Report. The Committee and design team members also reviewed the NAEP 2009 Science Framework, the College Board Science Standards for College Success, NSTA's Science Anchors initiative, and such seminal documents as the National Science Education Standards developed by the NRC and the Benchmarks for Science Literacy developed by AAAS.

### **What are scientific practices?**

Scientific practices are the behaviors that scientists engage in as they investigate and build models and theories about the natural world. The NRC uses the term practices instead of a term like "skills" to emphasize that engaging in scientific inquiry requires coordination of both knowledge and skills simultaneously. Use of the term practices helps avoid the interpretation of skill as rote mastery of an activity or procedure. Part of the NRC's intent is to better explain and extend what is meant by "inquiry" in science and the range of cognitive, social, and physical practices that it requires.

Like previous editions of science standards from the NRC and AAAS, science practices will also include practices of engineering, which are the behaviors that engineers engage in as they apply science and mathematics to design solutions to problems. Although engineering design is similar to scientific inquiry there are significant differences. For example, scientific inquiry involves the formulation of a question that can be answered through investigation, while engineering design involves the formulation of a problem that can be solved through design. Strengthening the engineering aspects of the Next Generation Science Standards will clarify for students the relevance of science, technology, engineering and mathematics (the four STEM fields) to everyday life. And engaging in these practices help students become successful analytical thinkers, prepared for college and careers.

### **What are crosscutting concepts?**

The NRC Framework describes crosscutting concepts as those that bridge disciplinary boundaries, having explanatory value throughout much of science and engineering. Crosscutting concepts help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world. These are as follows: Patterns; Cause and effect: Mechanism and explanation; Scale, proportion and quantity; Systems and system models; Energy and matter: Flows, cycles, and

conservation; Structure and function; Stability and change. The Framework also emphasizes that these concepts need to be made explicit for students because they provide an organizational schema for interrelating knowledge from various science fields into a coherent and scientifically-based view of the world.

### **Standards Development Process**

#### **How is the development of the Next Generation Science Standards different than the development of the Common Core State Standards?**

The Next Generation Science Standards (NGSS) is following a different developmental pathway than did the Common Core State Standards (CCSS) in English language arts and mathematics. The process for the science standards development takes into account the importance of having the scientific and educational research communities identify core ideas in science, articulate them across grade bands, and provide on-going advice throughout the process. That is why the NRC took the first step by constructing a Framework for K–12 Science Education—to ensure scientific validity and accuracy. A committee of 18 experts in science, engineering, cognitive science, teaching and learning, curriculum, assessment and education policy, was responsible for writing the Framework. The Framework describes a vision of what it means to be proficient in science; it rests on a view of science as both a body of knowledge and an evidence-based, model and theory building enterprise that continually extends, refines, and revises knowledge. It also presents and explains the interrelationships among practices, cross-disciplinary concepts and disciplinary core ideas. The NRC released a draft for public comment during the summer of 2010 and the final report in July of 2011.

Achieve will facilitate the next step: a state-led process where state policy leaders, higher education, K–12 teachers, the science and business community and others will develop science standards that are grounded in the Framework. This second step recognizes the importance of state and educator leadership in the development of the actual standards. Moreover, all stakeholders can expect that there will be multiple opportunities for public feedback, review and discussion just as there were in the CCSS process.

#### **Is the federal government involved in the development of the Next Generation Science Standards?**

No. The federal government is not involved in this effort. It is state-led, and states will decide whether or not to adopt the standards. The work undertaken by both the NRC and Achieve is being supported by the Carnegie Corporation of New York. No federal funds have or will be used to develop the standards.

#### **Who will be involved in the development of the Next Generation Science Standards?**

The development of the Standards will be a state-led effort. In addition to states, the NRC, the National Science Teachers Association (NSTA), AAAS, and other critical partners such as the Council of Chief State School Officers (CCSSO), the Council of State Science Supervisors (CSSS), and the National Governors Association (NGA) will be active in the development and review of the new standards and will provide significant strategic support to states. Writing and review teams will consist of K–12 teachers, state science and policy staff, higher education faculty, scientists, engineers, cognitive scientists, and business leaders.



**Will there be an opportunity for the general public to submit feedback on the standards during the development process?**

Yes. The Next Generation Science Standards will have two public web-based feedback periods prior to the finalization of the standards. In addition, state leaders, teachers, scientific and educator organizations, higher education faculty, scientists and business community members will review drafts at specific intervals.

**What is the timeline for completing the Next Generation Science Standards?**

The current timeline is designed to complete the standards by fall 2012.

**Will there be an alignment of the Next Generation Science Standards to the National Research Council's Framework for K–12 Science Education?**

During development, a feedback loop between Achieve and the National Academies will ensure fidelity of the standards to the Framework.

### **Next Steps for the Standards and Framework**

**Will the new standards be the Common Core State Standards for Science?**

In the end, the decision to adopt the standards will lie in the hands of the states themselves. The goal is to create robust K–12 science standards that all states can use to guide teaching and learning in science for the next decade. Thus, the National Academies, Achieve, NSTA, and AAAS are working collaboratively with states and other stakeholders to help ensure the standards will be of high quality—internationally benchmarked, rigorous, research-based and aligned with expectations for college and careers.

**How will states use these standards documents?**

To reap the benefits of the science standards, states should adopt them in whole, without alteration. States can use the NGSS, as they are using the CCSS in English language arts and mathematics, to align curriculum, instruction, assessment, and professional preparation and development.

**How will states use the NRC Framework?**

The NRC Framework articulates a vision for science learning and teaching. States can start implementing changes to their systems for professional development and pre-service teacher training based on a deep understanding of this vision. They can also begin to think about ways to align curriculum, instruction and assessment with this vision. Once the Next Generation Science Standards are developed, the process of alignment can begin in earnest.

**Will there be science assessments aligned to the NGSS?**

States will decide whether to create common assessments aligned to the Next Generation Science Standards.

# 5 Things Every Teacher Should be Doing to Meet the Common Core State Standards



by Lauren Davis, Senior Editor, Eye On Education



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# 5 Things Every Teacher Should be Doing to Meet the Common Core State Standards

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**W**hen reading the Common Core State Standards, it's easy to get caught up in the details of each standard. ("Okay, I need to teach compound-complex sentences.") However, it's also important to take a step back and reflect on the big picture. How will the standards change your teaching approaches? How do the standards alter the definition of what it means to be an effective teacher in the 21st century?

The Common Core State Standards highlight five shifts that should be happening in every classroom. Teachers should:

- Lead High-Level, Text-Based Discussions
- Focus on Process, Not Just Content
- Create Assignments for Real Audiences and with Real Purpose
- Teach Argument, Not Persuasion
- Increase Text Complexity

We'll explore each of these items in more detail.

# 5 Things Every Teacher Should be Doing to Meet the Common Core State Standards

## Lead High-Level, Text-Based Discussions

When you ask students to discuss a text as a whole class or in small groups, make sure that your questions are grounded in the text, and that students refer to the text in their responses. You may wish to begin a discussion by focusing on an author's word choice and then moving to the bigger picture. In *Publishers' Criteria for the Common Core State Standards in English Language Arts and Literacy*, David Coleman and Susan Pimentel, two authors of the standards, explain:

An effective set of discussion questions might begin with relatively simple questions requiring attention to specific words, details, and arguments and then move on to explore the impact of those specifics on the text as a whole. Good questions will often linger over specific phrases and sentences to ensure careful comprehension and also promote deep thinking and substantive analysis of the text (p.7).

**You can also ask students for their opinions and personal reactions, but Coleman and Pimentel argue that you should not begin with such an approach.**

You can also ask students for their opinions and personal reactions, but Coleman and Pimentel argue that you should not begin with such an approach.

The Common Core State Standards call for students to demonstrate a careful understanding of what they read before engaging their opinions, appraisals, or interpretations.... Often, curricula surrounding texts leap too quickly into broad and wide-open questions of interpretation before cultivating command of the details and specific ideas in the text (p. 9).

Of course, even if you craft strong questions, you cannot assume that students know how to be effective participants in a class discussion. In *Teaching Critical Thinking*, Terry Roberts and Laura Billings speak about the importance of explicitly teaching speaking and listening skills, which are emphasized in the Common Core. For example, have students set goals before a discussion. Goals might include:

- Speak at least three times
- Agree or disagree with someone else in detail
- Ask a question
- Keep an open mind (Roberts and Billings, p. 21).

After the discussion, you can ask students to assess how they did. Eventually, students will become skilled at holding high-level discussions on their own.

## Focus on Process, Not Just Content

Content knowledge obviously matters. However, the Common Core State Standards stress the importance of student discovery. In other words, we cannot merely fill students' heads with content; we should provide them with opportunities to discover information on their own. For example, when teaching vocabulary, we shouldn't ask students to memorize a list of words. Instead, we should engage students in the gathering-information and learning process. Give students the opportunity to really understand the word and connect it to their own lives. "When students make multiple connections between a new word and their own experiences, they develop a nuanced and flexible understanding of the word they are learning" (The Common Core State Standards, Appendix A, p. 32).



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In *Vocabulary at the Center*, Benjamin and Crow describe what discovery-based word study could look like in the classroom:

An example of a meaningful engagement would be for students to create a blog about a topic of interest and carry on an online conversation that is laced with target words. Even if the target words do sound forced, at least the student is combing through the new vocabulary in search of words that actually communicate their ideas (p. 117).

In that activity, students are discovering how words can help them communicate. They are not memorizing a bunch of random words that they will forget days later. They are learning how to learn and use new words, a skill that will stay with them throughout school and beyond.

The Common Core State Standards also emphasize the learning process in relation to research. The standards emphasize “extensive practice with short, focused research projects” (Coleman and Pimentel, p. 11). The purpose of research isn’t just to learn about a topic but to become familiar with the research process itself. Students should “repeat the research process many times and develop the expertise needed to conduct research independently” (Coleman and Pimentel, p. 11). As a result of this repeated practice, students will understand the research process and will be able to carry it out on their own later. Students will become “self-directed learners, effectively seeking out and using resources to assist them, including teachers, peers, and print and digital reference materials” (The Common Core State Standards, Introduction, p. 7).

### Create Assignments for Real Audiences and with Real Purpose

The standards emphasize the importance of writing for a variety of audiences. Students should “write routinely over extended time frames...for a range of tasks, purposes, and audiences” (p. 41). Of course, you could teach audience by making up a fake audience each time you assign a project. (“Pretend you’re writing a letter to a chef, asking him to change the menu to suit vegetarians. Pretend you’re giving a speech to the Board of Ed.”) However, if our goal is to prepare students for college and career readiness, why not use real audiences and give students more authentic experiences, like the ones they will have later?

In *Tween Crayons and Curfews*, Heather Wolpert-Gawron discusses the importance of creating assignments that require students to “develop an authentic goal” and use “authentic skills in which to achieve it” (p. 60). For example, at her school, the school bell made an unpleasant noise. The students decided that they wanted the bell to be fixed. They developed a thesis, organized a petition, wrote letters, and prepared an oral statement to be read for the principal and vice principal. Because they were working on a real issue and had to present their findings to real people, they were more motivated to do a good job. In addition, these students are more prepared to write for and present to real audiences in the future.

### Teach Argument, Not Persuasion

Some people use the terms *argument* and *persuasion* synonymously; however, the Common Core State Standards draw a distinction between the two. According to Appendix A of the CCSS, persuasive writing might “appeal to the audience’s self-interest, sense of identity, or emotions,” whereas a logical argument “convinces the audience because of the perceived merit and reasonableness of the claims and proofs offered rather than either the emotions the writing evokes in the audience or the character or credentials of the writer” (p. 24). The following table shows some common elements of each genre.



## 5 Things Every Teacher Should be Doing to Meet the Common Core State Standards

### Persuasion vs. Argument

Genre	Definition	Common Features
Persuasion	Appeals to the emotions of the audience	Uses techniques such as bandwagon, plain folks, glittering generalities, name calling, and snob appeal
Argument	Appeals to logic and reason	Consists of a thesis/claim, evidence, concession/refutation, and a more formal style

The CCSS favor argument over persuasion because it requires more logic and reason, and is more in line with the kind of writing that students will be expected to do in college. Teachers may wish to rethink the kinds of prompts they assign. For example, instead of asking students to persuade the principal to extend recess, have students write a research-based argument about the importance of recess and physical activity. This is not to say that there isn't a place for persuasion in the classroom. Teaching persuasive techniques such as bandwagon can be useful when doing a media literacy unit and having students analyze advertisements, for example. However, the CCSS ask that teachers make argument a higher priority in the classroom.

### Increase Text Complexity

Text complexity is a key aspect of the Common Core State Standards. According to Coleman and Pimentel:

Research makes clear that the complexity levels of the texts students are presently required to read are significantly below what is required to achieve college and career readiness. The Common Core State Standards hinge on students encountering appropriately complex texts at each grade level to develop the mature language skills and the conceptual knowledge they need for success in school and life (p. 3).

Coleman and Pimentel refer to "appropriately complex texts at each grade level." But how can teachers choose texts that are at the right level? Appendix A of the standards recommends that teachers use a combination of qualitative and quantitative measures (p. 8). Don't rely solely on Lexiles or other formulas, even though they seem "official." The formulas are imperfect and do not take subject matter into account. Use your own judgment. Also be careful not to choose material that is too challenging. In *Rigor Made Easy*, Barbara Blackburn stresses the importance of balance:

Look for balance: material should be difficult enough that students are learning something new, but not so hard that they give up. If you like to play tennis, you'll improve if you play against someone who is better than you. But if you play against Venus and Serena Williams, you'll learn less because you are overwhelmed by their advanced skill level (p. 19).

**Besides making sure that an individual text is challenging enough, you can also raise the level of content in your classroom by using multiple sources of information. Providing multiple sources on the same topic can help students see a variety of perspectives, and it can help students adjust to texts at varying levels of difficulty.**

# 5 Things Every Teacher Should be Doing to Meet the Common Core State Standards

Besides making sure that an individual text is challenging enough, you can also raise the level of content in your classroom by using multiple sources of information. Providing multiple sources on the same topic can help students see a variety of perspectives, and it can help students adjust to texts at varying levels of difficulty. For example:

After reading the fictional book *The Watsons Go to Birmingham—1963*, by Christopher Paul Curtis, students can read nonfiction online, encyclopedia articles, and/or magazine articles to compare the story to Birmingham, Alabama, during the civil rights period. You could add another step by reading current newspaper and magazine articles to compare it to Birmingham today, detailing the changes that have occurred (Blackburn, p. 24).

By exposing students to various sources on the same topic, you are adding more depth and perspective to the lesson.

## Summary

As you align your curriculum to the Common Core State Standards, don't forget to pause and reflect on the big picture. How are these five shifts happening in your classroom? What have you already been doing well? What would you like to change? Adjusting your lessons to cover the standards will take time and work. Stopping to ask yourself questions along the way can help you achieve success.

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## Common Core State Standards Initiative Standards-Setting Considerations

The following considerations guided the standards development workgroups in setting the draft college and career readiness standards.

**Fewer, clearer, higher:** One of the goals of this process was to produce a set of fewer, clearer and higher standards. It is critical that any standards document be translatable to and teachable in the classroom. As such, the standards must cover only those areas that are critical for student success. This meant making tough decisions about what to include in the standards; however, these choices were important to ensure the standards are useable by teachers.

**Evidence:** This work has made unprecedented use of evidence in deciding what to include – or not include – in the standards. Each document includes a brief narrative on the choices that were made based on evidence. Rather than focusing on the *opinions* of experts exclusively, evidence to guide the decisions about what to include in the standards was used. This is a key difference between this process and the processes that have come before.

**Internationally benchmarked:** These standards are informed by the content, rigor and organization of standards of high-performing countries and states so that all students are prepared to succeed in a global economy and society.

**Special populations:** In the development of these standards, the inclusion of all types of learners was a priority. Writers selected language intended to make the standards documents accessible to different learners.

**Assessment:** While an assessment of the common core state standards is not currently being developed, these standards will ultimately be the basis for an assessment system that would include multiple measures of student performance. Once states agree on the final standards, attention will be turned to creating a high quality system of measurement that would include proper incentives for teachers to teach these standards and a variety of assessments that will reinforce teaching and learning tied to the agreed upon expectations.

**Standards and curriculum:** Standards are not curriculum. This initiative is about developing a set of standards that are common across states. The curriculum that follows will continue to be a local responsibility (or state-led, where appropriate). The curriculum could become more consistent from state to state based on the commonality of the standards; however, there are multiple ways to teach these standards, and therefore, there will be multiple approaches that could help students accomplish the goals set out in the standards.

## Conceptual Shifts in the Next Generation Science Standards

The Next Generation Science Standards (NGSS) provide an important opportunity to improve not only science education but also student achievement. Based on the *Framework for K–12 Science Education*, the NGSS are intended to reflect a new vision for American science education. The following conceptual shifts in the NGSS demonstrate what is new and different about the NGSS:

### 1. K–12 Science Education Should Reflect the Real World Interconnections in Science.

*"The framework is designed to help realize a vision for education in the sciences and engineering in which students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields."*<sup>1</sup>

The vision represented in the *Framework* is new in that students must be engaged at the nexus of the three dimensions:

1. Science and Engineering Practice,
2. Crosscutting Concepts, and
3. Disciplinary Core Ideas.

Currently, most state and district standards express these dimensions as separate entities, leading to their separation in both instruction and assessment. Given the importance of science and engineering in the 21<sup>st</sup> century, students require a sense of contextual understanding with regard to scientific knowledge, how it is acquired and applied, and how science is connected through a series of concepts that help further our understanding of the world around us. Student performance expectations have to include a student's ability to apply a practice to content knowledge, thereby focusing on understanding and application as opposed to memorization of facts devoid of context. The *Framework* goes on to emphasize that:

*"...learning about science and engineering involves integration of the knowledge of scientific explanations (i.e., content knowledge) and the practices needed to engage in scientific inquiry and engineering design. Thus the framework seeks to illustrate how knowledge and practice must be intertwined in designing learning experiences in K–12 science education."*<sup>2</sup>

<sup>1</sup> (2011). *A Framework for K–12 Science Education: Practices, crosscutting concepts, and core ideas*. (p. 10). Washington, DC: The National Academies Press. Retrieved from [http://www.nap.edu/catalog.php?record\\_id=13165](http://www.nap.edu/catalog.php?record_id=13165)

<sup>2</sup> (2011). *A Framework for K–12 Science Education: Practices, crosscutting concepts, and core ideas*. (p. 11). Washington, DC: The National Academies Press. Retrieved from [http://www.nap.edu/catalog.php?record\\_id=13165](http://www.nap.edu/catalog.php?record_id=13165)



**2. Science and Engineering Practices and Crosscutting Concepts should not be taught in a vacuum; they should always be integrated with multiple core concepts throughout the year.** As stated previously, past science standards at both the state and district levels have treated the three dimensions of science as separate and distinct entities leading to preferential treatment in assessment or instruction. It is essential to understand that the emphasis placed on a particular Science and Engineering Practice or Crosscutting Concept in a performance expectation is not intended to limit instruction, but to make clear the intent of the assessments.

An example of this is best illustrated in two performance expectations in high school physical sciences. The practice of modeling is a significant change on its own. Models are basically used for three reasons; 1) to represent or describe, 2) to collect data, or 3) to predict. The first use is typical in schools since models and representations are usually synonymous. However, the use of models to collect data or to predict phenomena is new, for example:

*Construct models to explain changes in nuclear energies during the processes of fission, fusion, and radioactive decay and the nuclear interactions that determine nuclear stability.*

and

*Use system models (computer or drawings) to construct molecular-level explanations to predict the behavior of systems where a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.*

In the first performance expectation, models are used with nuclear processes to explain changes. A scientific explanation requires evidence to support the explanation, so students will be called upon to construct a model for the purpose of gathering evidence to explain these changes. Additionally, they will be required to use models to both explain and predict the behavior of systems in equilibrium. Again, the models will have to be used to collect data, but they will be further validated in their ability to predict the state of a system. In both cases, students will need a deep understanding of the content, as well as proficiency in the ability to construct and use models for various applications. The practice of modeling will need to be taught throughout the year—and indeed throughout the entire K–12 experience—as opposed to during one two-week unit of instruction.

The goal of the NGSS is to be clear about which practice students are responsible for in terms of assessment, but these practices and crosscutting concepts should occur throughout each school year.



### 3. Science Concepts Build Coherently Across K–12.

The focus on a few Disciplinary Core Ideas is a key aspect to a coherent science education. The *Framework* identified a basic set of core ideas that are meant to be understood by the time a student completes high school:

*“To develop a thorough understanding of scientific explanations of the world, students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas’ interconnections over a period of years rather than weeks or months [1]. This sense of development has been conceptualized in the idea of learning progressions [1, 25, 26]. If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination. Such progressions describe both how students’ understanding of the idea matures over time and the instructional supports and experiences that are needed for them to make progress.”<sup>3</sup>*

There are two key points that are important to understand:

- First, focus and coherence must be a priority. What this means to teachers and curriculum developers is that the same ideas or details are not covered each year. Rather, a progression of knowledge occurs from grade band to grade band that gives students the opportunity to learn more complex material, leading to an overall understanding of science by the end of high school. Historically, science education was taught as a set of disjointed and isolated facts. The *Framework* and the NGSS provide a more coherent progression aimed at overall scientific literacy with instruction focused on a smaller set of ideas, but with an eye on what the student should have already learned and what they will learn at the next level.
- Second, the progressions in the NGSS automatically assume that previous material has been learned by the student. Choosing to omit content at any grade level or band will impact the success of the student toward understanding the core ideas and puts additional responsibilities on teachers later in the process.

### 4. The NGSS Focus on Deeper Understanding and Application of Content.

The *Framework* identified a smaller set of Disciplinary Core Ideas that students should know by the time they graduate from high school and the NGSS are written to focus on the same. It is important that teachers and curriculum/assessment developers understand that the focus is on the core ideas—not necessarily the facts that are associated with them. The facts and details are important evidence, but not the sole focus of instruction. The *Framework* states,

*“The core ideas also can provide an organizational structure for the acquisition of new knowledge. Understanding the core ideas and engaging in the scientific and engineering*

<sup>3</sup> (2011). *A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas*. (p. 26). Washington, DC: The National Academies Press. Retrieved from [http://www.nap.edu/catalog.php?record\\_id=13165](http://www.nap.edu/catalog.php?record_id=13165)

*practices helps to prepare students for broader understanding, and deeper levels of scientific and engineering investigation, later on—in high school, college, and beyond. One rationale for organizing content around core ideas comes from studies comparing experts and novices in any field. Experts understand the core principles and theoretical constructs of their field, and they use them to make sense of new information or tackle novel problems. Novices, in contrast, tend to hold disconnected and even contradictory bits of knowledge as isolated facts and struggle to find a way to organize and integrate them [24]. The assumption, then, is that helping students learn the core ideas through engaging in scientific and engineering practices will enable them to become less like novices and more like experts.”<sup>4</sup>*

## **5. Science and Engineering are Integrated in Science Education from K–12.**

The idea of integrating technology and engineering into science standards is not new. Chapters on the nature of technology and the human-built world were included in *Science for All Americans* (AAAS 1989) and *Benchmarks for Science Literacy* (AAAS 1993, 2008). Standards for “Science and Technology” were included for all grade spans in the *National Science Education Standards* (NRC 1996).

Despite these early efforts, however, engineering and technology have not received the same level of attention in science curricula, assessments, or the education of new science teachers as the traditional science disciplines have. A significant difference in the *Next Generation Science Standards* (NGSS) is the integration of engineering and technology into the structure of science education by raising engineering design to the same level as scientific inquiry in classroom instruction when teaching science disciplines at all levels, and by giving core ideas of engineering and technology the same status as those in other major science disciplines.

The rationale for this increased emphasis on engineering and technology rests on two positions taken in *A Framework for K–12 Science Education* (NRC 2011). One position is aspirational; the other practical.

From an aspirational standpoint, the *Framework* points out that science and engineering are needed to address major world challenges such as generating sufficient clean energy, preventing and treating diseases, maintaining supplies of food and clean water, and solving the problems of global environmental change that confront society today. These important challenges will motivate many students to continue or initiate their study of science and engineering.

From a practical standpoint, the *Framework* notes that engineering and technology provide opportunities for students to deepen their understanding of science by applying their developing

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<sup>4</sup> (2011). *A Framework for K–12 Science Education: Practices, crosscutting concepts, and core ideas*. (p. 25). Washington, DC: The National Academies Press. Retrieved from [http://www.nap.edu/catalog.php?record\\_id=13165](http://www.nap.edu/catalog.php?record_id=13165)

scientific knowledge to the solution of practical problems. Both positions converge on the powerful idea that by integrating technology and engineering into the science curriculum teachers can empower their students to use what they learn in their everyday lives.

#### **6. Science Standards Coordinate with English Language Arts and Mathematics Common Core State Standards.**

The timing of the release of NGSS comes as most states are implementing the Common Core State Standards (CCSS) in English Language Arts and Mathematics. This is important to science for a variety of reasons. First, there is an opportunity for science to be part of a child's comprehensive education. The NGSS are aligned with the CCSS to ensure a symbiotic pace of learning in all content areas. The three sets of standards overlap in meaningful and substantive ways and offer an opportunity to give all students equitable access to learning standards.

Some important work is already in progress regarding the implications and advantages to the CCSS and NGSS. Stanford University recently released 13 papers on a variety of issues related to language and literacy in the content areas of the CCSS and NGSS.<sup>5</sup>

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<sup>5</sup> Stanford University. (2012). *Understanding language*. Retrieved from <http://ell.stanford.edu/papers>.

## Grade K Overview

### Counting and Cardinality

- Know number names and the count sequence.
- Count to tell the number of objects.
- Compare numbers.

### Operations and Algebraic Thinking

- Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from.

### Number and Operations in Base Ten

- Work with numbers 11–19 to gain foundations for place value.

### Measurement and Data

- Describe and compare measurable attributes.
- Classify objects and count the number of objects in categories.

### Geometry

- Identify and describe shapes.
- Analyze, compare, create, and compose shapes.

### Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Math

# ELA - English Language Arts

## College and Career Readiness Anchor Standards for Reading

The K-5 standards on the following pages define what students should understand and be able to do by the end of each grade. They correspond to the College and Career Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

### Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze how and why individuals, events, and ideas develop and interact over the course of a text.

### Craft and Structure

4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

### Integration of Knowledge and Ideas

7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.\*
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

### Range of Reading and Level of Text Complexity

10. Read and comprehend complex literary and informational texts independently and proficiently.

### Note on range and content of student reading

To build a foundation for college and career readiness, students must read widely and deeply from among a broad range of high-quality, increasingly challenging literary and informational texts. Through extensive reading of stories, dramas, poems, and myths from diverse cultures and different time periods, students gain literary and cultural knowledge as well as familiarity with various text structures and elements. By reading texts in history/social studies, science, and other disciplines, students build a foundation of knowledge in these fields that will also give them the background to be better readers in all content areas. Students can only gain this foundation when the curriculum is intentionally and coherently structured to develop rich content knowledge within and across grades. Students also acquire the habits of reading independently and closely, which are essential to their future success.

\*Please see "Research to Build and Present Knowledge" in Writing and "Comprehension and Collaboration" in Speaking and Listening for additional standards relevant to gathering, assessing, and applying information from print and digital sources.



## Core Curriculum Resources

Language Arts	Science
<ul style="list-style-type: none"> <li>• biography</li> <li>• autobiography</li> <li>• short story</li> <li>• novel</li> <li>• diary</li> <li>• student journal</li> <li>• play</li> <li>• prop/costume</li> <li>• reader's theater</li> <li>• literary analysis</li> <li>• speech (written and recorded)</li> <li>• poem</li> <li>• literature and grammar textbook</li> <li>• literature guide (e.g., Novel-Ties, Scholastic, etc.)</li> <li>• video</li> <li>• grammar textbook</li> <li>• book on tape</li> <li>• music</li> <li>• artwork</li> <li>• genre-specific writing rubric (e.g., response to literature, persuasive, etc.)</li> <li>• field trip (e.g., play, symphony, etc.)</li> <li>• VoiceThread (digital tool for sharing stories or conversations with people around the world via voice, text, audio file, or video) <a href="http://voicethread.com/">http://voicethread.com/</a></li> <li>• folklore and mythology text <a href="http://www.pitt.edu/~dash/folktexts.html">http://www.pitt.edu/~dash/folktexts.html</a></li> <li>• Storykit (iPod app for creating, editing, and reading stories)</li> <li>• Common Core Standards for ELA, Appendix B: Text Exemplars and Sample Performance Tasks (NGA Center &amp; CCSSO, 2010)</li> <li>• Common Core Standards for ELA, Appendix C: Samples of Student Writing (NGA Center &amp; CCSSO, 2010)</li> </ul>	<ul style="list-style-type: none"> <li>• newspaper and magazine article (e.g., <i>American Science Journal</i>)</li> <li>• science journal article</li> <li>• photograph</li> <li>• field guide</li> <li>• documentary (e.g., <i>An Inconvenient Truth</i>, <i>Super Size Me</i>, etc.)</li> <li>• website (e.g., <a href="http://www.fossweb.com/">www.fossweb.com/</a> and <a href="http://www.topscience.org/">www.topscience.org/</a> for interactive activities; <a href="http://www.scholastic.com/home/">www.scholastic.com/home/</a> for teacher and parent resources; <a href="http://songsforteaching.com/">http://songsforteaching.com/</a> for music)</li> <li>• perishable lab materials (e.g., pig's intestine, frog, cow's eye, mealworms, crayfish, etc.)</li> <li>• specimens (e.g., rocks and minerals)</li> <li>• aquarium/terrarium</li> <li>• microscope</li> <li>• thermometer</li> <li>• telescope</li> <li>• magnifying lens</li> <li>• balances and scales</li> <li>• chart (e.g., periodic table, blood cells, mitosis/meiosis) and models (e.g., anatomy, torso, plant and animal cells, etc.)</li> <li>• test tube, beaker, plastic slide, petri dish</li> <li>• pH supplies (e.g., meter, papers, indicators, test set)</li> <li>• safety equipment (e.g., safety goggles, apron, plastic covers, etc.)</li> <li>• dissecting set</li> <li>• video (e.g., Bill Nye the Science Guy: <i>Atoms/Motion</i>, <i>The Magic School Bus</i>) and documentary</li> <li>• field trip (e.g., weather station, nature preserve, wetlands, planetarium, greenhouse, etc.)</li> <li>• science and technology school resource supplier (e.g., AIMS Educational Foundation, Fisher Science Education, etc.)</li> </ul>
Math	Social Studies
<ul style="list-style-type: none"> <li>• math textbook</li> <li>• math manipulatives (e.g., pattern blocks, spinners, tangrams, counters, etc.)</li> <li>• play money</li> <li>• individual whiteboard, markers, erasers</li> </ul>	<ul style="list-style-type: none"> <li>• documentary (e.g., <i>The Times of Harvey Milk</i>, <i>Why We Fight</i>, <i>Triumph of the Will</i>, etc.)</li> <li>• recorded and written speeches (e.g., Martin Luther King's "I Have a Dream"; see <a href="http://www.history.com/speeches">www.history.com/speeches</a>)</li> </ul>

<ul style="list-style-type: none"> <li>• math journal</li> <li>• math software programs</li> <li>• website (e.g., <a href="http://songsforteaching.com/">http://songsforteaching.com/</a>)</li> <li>• protractor</li> <li>• ruler</li> <li>• geometric shapes</li> <li>• calculator</li> <li>• two- and three-dimensional figures</li> <li>• bank statement/checkbook</li> <li>• stock report</li> <li>• data display</li> <li>• chart, graph, table, diagram</li> <li>• guest speaker (e.g., architect, engineer, dietician)</li> <li>• graphing paper</li> <li>• scales with weights</li> <li>• abacus</li> <li>• math literature (e.g., <i>Eating Fractions</i>, <i>From One to One Hundred</i>, <i>The Greedy Triangle</i>, <i>The Go-Around Dollar</i>, etc.)</li> <li>• books and materials by Marilyn Burns</li> </ul>	<ul style="list-style-type: none"> <li>• video (e.g., excerpt from <i>Roots</i>)</li> <li>• simulation (e.g., Interact materials at <a href="http://www.interact-simulations.com/">www.interact-simulations.com/</a>)</li> <li>• primary source document (e.g., Declaration of Independence, historical journal entries)</li> <li>• guest speaker (e.g., Holocaust survivor, history professor, historian, local politician, etc.)</li> <li>• field trip (e.g., courthouse, walking field trip around school or neighborhood, history museum, factory, etc.)</li> <li>• historical fiction (e.g., <i>Little House in the Big Woods</i>, <i>My Brother Sam Is Dead</i>, etc.)</li> <li>• WebQuest</li> <li>• graphic organizer (e.g., Venn diagram, outlines, T-chart, etc.)</li> <li>• magazine (e.g., <i>Time for Kids</i>, <i>Newsweek</i>, etc.) and newspapers</li> <li>• map, globe, atlas</li> <li>• Google Earth <a href="http://www.google.com/earth/index.html">www.google.com/earth/index.html</a></li> </ul>
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**FIGURE 5.10**

Retrieved from the companion website for *Mapping Comprehensive Units to the ELA Common Core Standards, K–5*, by Kathy Tuchman Glass. Thousand Oaks, CA: Corwin, [www.corwin.com](http://www.corwin.com). Copyright © 2012 by Corwin. All rights reserved. Reproduction authorized only for the local school site or nonprofit organization that has purchased this book.

## Resource Ideas for Any Classroom

General Resources	
<ul style="list-style-type: none"> <li>• biography</li> <li>• autobiography</li> <li>• short story</li> <li>• novel</li> <li>• diary</li> <li>• student journal</li> <li>• published journal</li> <li>• drama</li> <li>• reader's theater</li> <li>• graphic organizer</li> <li>• literary review and critique</li> <li>• speeches (audio and text)</li> <li>• poem</li> </ul>	<ul style="list-style-type: none"> <li>• encyclopedia</li> <li>• dictionary/thesaurus</li> <li>• website</li> <li>• computer/software</li> <li>• LCD projector</li> <li>• interactive whiteboard (Promethean or SMART Board)</li> <li>• document camera</li> <li>• artwork</li> <li>• calendar with pictures</li> <li>• photograph</li> <li>• music (CDs, cassettes)</li> <li>• primary source document</li> </ul>
<ul style="list-style-type: none"> <li>• textbook</li> <li>• video/audio</li> <li>• librarian</li> <li>• media specialist</li> <li>• PowerPoint presentation</li> <li>• magazine article</li> <li>• newspaper article</li> <li>• poster</li> <li>• pamphlet</li> <li>• brochure</li> </ul>	<ul style="list-style-type: none"> <li>• guest speaker</li> <li>• student handout (e.g., for homework, in-class assignments, journal prompts, etc.)</li> <li>• quiz and test</li> <li>• student checklist</li> <li>• published and student examples</li> <li>• scoring rubric</li> <li>• teacher resources (e.g., websites, college textbooks, literature guides, etc.)</li> <li>• content area standards</li> </ul>
Digital Resources	
<ul style="list-style-type: none"> <li>• LibriVox (free audiobooks from the public domain; several options for listening) <a href="http://librivox.org/">http://librivox.org/</a></li> <li>• Storynory (free audiobooks of original stories, fairy tales, myths and histories, poems) <a href="http://storynory.com/">http://storynory.com/</a></li> <li>• Poem Hunter (database of poems) <a href="http://www.poemhunter.com/">www.poemhunter.com/</a></li> <li>• Many Books (more than 29,000 free Ebooks) <a href="http://www.manybooks.net/">www.manybooks.net/</a></li> <li>• Wordle (tool to generate "word clouds" from text that students provide) <a href="http://www.wordle.net/">www.wordle.net/</a></li> <li>• WebQuests (web-based software for creating WebQuests in a short time without writing any HTML codes; see other educators' Webquests, as well) <a href="http://www.zunal.com/">www.zunal.com/</a></li> <li>• Bubbl.us (a tool that allows students to visually web/map understanding of words and concepts; free alternative to Kidspiration) <a href="https://bubbl.us/">https://bubbl.us/</a></li> <li>• iPod Touches</li> <li>• flip video camera</li> <li>• graphic organizers               <ul style="list-style-type: none"> <li>○ <a href="http://www.eduplace.com/graphicorganizer/">www.eduplace.com/graphicorganizer/</a></li> <li>○ <a href="http://www.edhelper.com/teachers/graphic_organizers.htm">www.edhelper.com/teachers/graphic_organizers.htm</a></li> <li>○ <a href="http://www.teachervision.fen.com/graphic-organizers/printable/6293.html">www.teachervision.fen.com/graphic-organizers/printable/6293.html</a></li> <li>○ <a href="http://freeology.com/graphicorgs/">http://freeology.com/graphicorgs/</a></li> <li>○ <a href="http://www.educationoasis.com">www.educationoasis.com</a></li> </ul> </li> </ul>	

### Primary Resources

- letter manipulatives (magnetic letters, rubber stamps, letter trace cards, alphabet tiles, etc.)
- individual mini-whiteboards with markers
- picture cards
- art supplies (crayons, gluesticks, glue dots, scissors, washable markers, feathers, Wikki stix)
- plastic tablecloths or shower curtain, plastic smocks
- stickers, bookmarks
- pocket chart, phoneme frames, sentence strips, sight words, flannel board
- finger puppets, stick figurines
- rhythm instruments (sticks, bells, triangle, tambourine)
- timers
- primary reference books (picture dictionary, beginning thesaurus, rhyming dictionary)

### FIGURE 5.9

Retrieved from the companion website for *Mapping Comprehensive Units to the ELA Common Core Standards, K–5*, by Kathy Tuchman Glass. Thousand Oaks, CA: Corwin, [www.corwin.com](http://www.corwin.com). Copyright © 2012 by Corwin. All rights reserved. Reproduction authorized only for the local school site or nonprofit organization that has purchased this book.

# Global Lessons

What can we learn from other countries about preparing young kids for the future? Plenty. Take an international tour to see how top educational systems help their students excel. *by CATHERINE HOLECKO*



To compete globally, we need to catch up in the classroom.

## FINLAND freedom to learn

It doesn't seem like a formula for success: Finnish kids start school later (at age 7) than kids in most countries and have far less homework than students in Asia and the U.S. Yet they rank near the top in reading, math, and science. How do the Finns do it?

"Teachers there have a very low-pressure, flexible approach," says filmmaker Bob Compton, whose documentary series on global education includes *The Finland Phenomenon: Inside the World's Most Surprising School System*. "In Finnish classrooms, you see a lot of hands-on activities—painting, drawing, working with

clay, playing music. The classes are small, and each one has two teachers." Children call instructors by their first name and often "track" with them for up to three years.

But there's rigor behind this seemingly laid-back atmosphere. Although kids under 7 may not enroll in formal classes, Montessori-style play schools and child-care centers (generally offered for free to parents) engage kids in creative play and help them acquire essential social skills. Finnish teachers possess degrees in the subjects they teach. New grads spend a full year doing hands-on training under the tutelage of a master instructor. This helps teachers assess students' skills and needs via observation, rather than merely by testing

KIDS: BLOOM IMAGE/GETTY IMAGES; FINLAND FLAG: ISTOCKPHOTO



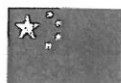
them. Whatever the topic of study—reading, writing, math—the emphasis is on teaching kids how to learn. “The point isn’t how many math problems they do but whether students have a conceptual understanding of the addition or subtraction they’re doing,” says Tony Wagner, Innovative Education Fellow at Harvard University and author of *Creating Innovators: The Making of Young People Who Will Change the World*.



## SINGAPORE top-tier teachers

Teaching is a high-status profession in this small island nation. Recruits tend to graduate in the top third of their class, and they complete a special training program. By the time they’re done, instructors have a deep-seated understanding of how kids learn, grow, and develop.

Singapore, which ranks in the world’s top five in math, science, and reading, focuses on school readiness for its preschoolers, says Elanna Yalow, Ph.D., chief executive officer of Knowledge Universe Early Learning Programs, which operates preschools and child-care centers in countries including Singapore and the U.S. Rigorous testing and tracking are the norm by grade school. Singapore’s business language is English, but most kids speak Mandarin, Malay, or Tamil as a second language at home or at school, and some learn a third or even a fourth language at certain schools, says Dr. Yalow. Still, the country’s educational system isn’t just about rote learning and memorization. “Ethics and citizenship are mandatory subjects in school,” says Charles Fadel, coauthor of *21st Century Skills: Learning for Life in Our Times*.



## CHINA logging long hours

In the U.S., the average length of the school day is about six and a half hours. By contrast, even preschoolers in

## What You Can Do

You may be thinking, “This all sounds intriguing, but I don’t have access to these systems for my child.” While that’s true, you can still have a major influence on her education. “We may not have control over the way a school teaches our kids, but we can manage the learning in our own home,” says Mei-Ling Hopgood, author of *How Eskimos Keep Their Babies Warm and Other Adventures in Parenting (From Argentina to Tanzania and Everywhere in Between)*. That’s something she learned in part from speaking with families from India, Pakistan, China, and Japan about their approach to academics. When parents didn’t feel their kids were getting enough in school, they looked for ways to supplement it. You can too.

- **Add more learning to your child’s day.** Sign him up for supplementary music and art classes, and take advantage of free storytime at the library.
- **Instill respect for teachers, school, and learning.** Play “school” at home to reinforce proper classroom manners like turn-taking, listening to the teacher, and

transitioning from one activity to another.

- **Expect excellence.** High-performing countries share a belief in the value of academics. “In China, being smart is cool,” recalls Laura Goertzel, an American who lived in Beijing with her diplomat husband when her first child was born. “The most popular kid is the one at the top of his class, as opposed to

the one who has the most up-to-date electronic gadget.” Nurture your child’s curiosity, responding with enthusiasm to the umpteen questions about how computers work or his request to read the *Encyclopedia of Dinosaurs* at bedtime ... again. Make sure you give him lots of new but achievable challenges so he keeps striving higher.

China put in eight-hour days, and by age 6, children have several hours of homework. “Parents here do everything they can to ensure that their one child succeeds and gets into a top college in this very competitive society,” says Stephanie Giambruno, an American TV producer and mom of a 4-year-old, who’s lived in Beijing for the past four years. “You don’t see Chinese primary-school kids playing outside, because they’re home doing schoolwork. Even on Saturdays, they’re taking English or getting ahead in other subjects.”

All this diligence has a big academic payoff. Chinese students ages 6 and older memorize complex Mandarin characters (as many as 50 new ones per week), master a second language (most commonly English), and delve far deeper into the study of science, taking three to four years each of biology, chemistry, and physics in high school compared with the typical one year each for most American students.



## NEW ZEALAND sharing their stories

You probably worry about how old your child should be when he starts using the Internet, but not so in New Zealand—where kids are encouraged to post their work online from a young age. “Students start using technology when they’re 5, drawing with simple graphics programs and dictating the captions to their teachers,” says Sarah McPherson, Ed. D., chair of the department of instructional technology at the New York Institute of Technology, in Old Westbury, New York, who took a recent tour of New Zealand schools. “By the time kids are in third grade, they’re posting their writing and drawings online independently.”

It’s all part of the Ministry of Education’s goal to create a generation of kids who express themselves and who take responsibility for their own learning. “Blogging is a way of giving the students a voice,” notes Dr. McPherson.

SINGAPORE FLAG: PAPER BOAT CREATIVE/GETTY IMAGES. CHINA AND NEW ZEALAND FLAGS: ISTOCKPHOTO.

**I ALWAYS SAY  
One good cookie  
deserves another.**

**We elves are teaming up  
with the American Red Cross,  
because the way we see it,  
even a small act of kindness,  
like donating blood, can add up  
to a whole lot of goodness.**

**That's why every time you  
donate, we want to reward you  
with a scrumptious cookie  
baked just for you.**



Give Blood Today American Red Cross

redcrossblood.org



PROUD SPONSOR OF THE  
AMERICAN RED CROSS

Become our fan on Facebook.

The American Red Cross name and emblem are used with its permission, which in no way constitutes an endorsement, express or implied, of any product, service, company, opinion or political position.

(To see some blogs by students in New Zealand, visit [ptengland.school.nz/index.php?mid=6](http://ptengland.school.nz/index.php?mid=6).)

## INDIA academic all-stars

Can you picture your child joining a team that competes not in soccer or tennis but in charades? She could, if she lived in India. Elocution, chess, and, yes, charades tournaments in India draw hundreds of spectators, which reflects the country's emphasis on creative thinking. From a young age, students are pushed to join in extracurriculars that reinforce academic skills over physical ones. "When you play charades, you're communicating nonverbally with your teammates, and they have to interpret what you're saying," says Compton. "It requires considerable creativity and problem-solving."

Some Indian schools have also started teaching Vedic mathematics, an ancient Hindu system of formulas known as sutras. By applying the 16 rules to a variety of equations, such as those involving multiplication and fractions, students use these skills to get an edge on competitive exams.

## JAPAN order in the class

Surprisingly, the Japanese have found that larger class sizes (about 28 per primary school, compared with 23 in the U.S.) make for more effective teaching: When one teacher instructs a larger group of kids, it frees up colleagues to spend time on collaboration, lesson planning, and one-on-one tutoring as needed. "The classrooms are more structured than in the U.S., and the teacher has total control," says Verna Kimura, an educational consultant who lived and taught in Japan for more than two decades. "And the kids compete at every level, starting with the struggle to gain entry to the most

sought-after kindergartens." The Japanese believe that good study habits in the younger years establish a pattern that kids will stick with as they get older. By age 6 or 7, students are taught specific test-taking skills, such as how to use the process of elimination to find the correct multiple-choice answer. "As intense as this approach may seem, the atmosphere helps build resilience and responsibility," says Kimura.

## CANADA a smooth segue

Katie York is grateful for the province of Ontario's unique pre-K program. When the time came to enroll her daughter, Gemma, now 6, she had a choice of four free, publicly funded school systems in her city, Toronto: English language, English Catholic, Francophone, and French Catholic. Ontario parents can also enroll their kid in junior kindergarten (JK) at age 3½; classrooms are shared with 4- and 5-year-olds (known as senior kindergartners, or SKs).

Volunteering in the classroom, which is encouraged but not required, provided York with an inside look at how the multiage approach works. For instance, SKs might have one-on-one preliteracy skills with a teacher or student volunteers from older grades, while JKs will work on an art project that focuses on the same topic. "It's amazing to see how it all fits together, and how Gemma's abilities expanded between JK and SK," says York. Parents also receive a detailed curriculum and learning plan, so they can complement a child's education at home. ☺

## get more!

Learn how to instill creativity, perseverance, and other skills your child needs to succeed in the future. Read our whole Thrive in 2025 series at [parents.com/thrive](http://parents.com/thrive).

ISTOCKPHOTO.



## BOX ES.1

## The Three Dimensions of the Framework

1. Scientific and Engineering Practices	3. Disciplinary Core Ideas
<ol style="list-style-type: none"> <li>1. Asking questions (for science) and defining problems (for engineering)</li> <li>2. Developing and using models</li> <li>3. Planning and carrying out investigations</li> <li>4. Analyzing and interpreting data</li> <li>5. Using mathematics and computational thinking</li> <li>6. Constructing explanations (for science) and designing solutions (for engineering)</li> <li>7. Engaging in argument from evidence</li> <li>8. Obtaining, evaluating, and communicating information</li> </ol> <p><b>2. Crosscutting Concepts</b></p> <ol style="list-style-type: none"> <li>1. Patterns</li> <li>2. Cause and effect: Mechanism and explanation</li> <li>3. Scale, proportion, and quantity</li> <li>4. Systems and system models</li> <li>5. Energy and matter: Flows, cycles, and conservation</li> <li>6. Structure and function</li> <li>7. Stability and change</li> </ol>	<p><u>Physical Sciences</u></p> <p>PS 1: Matter and its interactions</p> <p>PS 2: Motion and stability: Forces and interactions</p> <p>PS 3: Energy</p> <p>PS 4: Waves and their applications in technologies for information transfer</p> <p><u>Life Sciences</u></p> <p>LS 1: From molecules to organisms: Structures and processes</p> <p>LS 2: Ecosystems: Interactions, energy, and dynamics</p> <p>LS 3: Heredity: Inheritance and variation of traits</p> <p>LS 4: Biological evolution: Unity and diversity</p> <p><u>Earth and Space Sciences</u></p> <p>ESS 1: Earth's place in the universe</p> <p>ESS 2: Earth's systems</p> <p>ESS 3: Earth and human activity</p> <p><u>Engineering, Technology, and the Applications of Science</u></p> <p>ETS 1: Engineering design</p> <p>ETS 2: Links among engineering, technology, science, and society</p>

## **Kindergarten Story Lines**

Kindergarten students explore patterns in the natural and designed world in order to provide a structure for organizing scientific and technical information. Students explore patterns in weather, observable physical properties of matter, and plants and animals. Patterns are used in first grade as a means to identify cause and effect relationships.

### **K. Weather and Climate**

Students explore patterns and variations in local weather and its effect on their lives, creating a foundation for the understanding of climate and the impacts of weather related hazards in third grade. This topic lends itself to observations and investigations that allow kindergartners to acquire skills in analyzing and interpreting data using simple charts and diagrams to discover patterns. In addition, kindergartners share information gathered through investigation or research with others and use that information, as well as tools, to design a solution to a problem. Kindergarten students learn about cause and effect and ask what might be causing the patterns they observe, which is a focus in first grade. Students are expected to demonstrate an understanding of the weather typical of their local area, including severe weather and how forecasts allow people to prepare for weather events. In addition, kindergartners are expected to demonstrate understanding of how information learned in science is shared and used by people to improve their lives.

### **K. Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment**

The needs of plants and animals is introduced in kindergarten, and provides a foundation for learning about the interdependence of organisms and their surroundings in second grade, about the effect of changes in their environment on organisms in third grade, and about matter and energy in ecosystems in fifth grade. This topic lends itself to combining both direct observation of plants and animals and their surroundings, and obtaining additional information through use of other media (e.g., films, books) to construct explanations. The crosscutting concept of systems is introduced in this topic. Students engineer ways to reduce the impact of human use of resources to meet their needs. Students are expected to demonstrate understanding that plants and animals have particular needs and live in places where their needs are met.

### **K. Structure and Properties of Matter**

Observable properties of materials are introduced in kindergarten and create a foundation for second grade in which students measure physical properties of matter. This topic lends itself to kindergartners' innate curiosity by having them ask questions and investigate. There are many types of patterns in science and this is an introduction to one type of pattern, that of using similarities and differences for classification. This is the first time students are made consciously aware of the relationship between the natural and designed world through observation. Students deepen their understanding of this relationship throughout their education. Students observe and investigate the world around them to find answers to their questions. Students are expected to demonstrate understanding that properties of matter can be observed.





## **First Grade Storylines**

First grade students focus on using patterns as a means to identify cause and effect relationships. Students consider the effect structure has on survival; as well as, patterns in the night sky. Students use this information as they explore how cause and effect relationships affect stability and change within systems.

### **1. Structure, Function, and Information Processing**

Students learn about the external parts of plants and animals and how they are used, including variations of features among individuals and changes during growth. This topic builds on kindergarten understanding of the needs of plants and animals and supports later topics in fourth grade on the structure and function of internal and external parts of organisms. This topic lends itself to early experiences with the practice of using models (i.e., diagrams, drawings, physical replicas) and the crosscutting concept of structure and function. Students extend their understanding of engineering by applying their science knowledge about a plant or animal structure to design a solution to a problem. Students are expected to demonstrate understanding that plants and animals have a variety of external parts, and that the parts have uses which enable organisms to survive and meet their needs.

### **1. Space Systems: Patterns and Cycles**

Students learn about patterns of natural events, as well as patterns of objects in the sky. Students understand that some forms of technology can be useful tools in observing more objects in the night sky and in detail. This topic supports later learning in fifth grade when students use models to describe cyclic patterns and use scientific knowledge of light and lenses to design a tool to enhance vision. This topic lends itself to making observations and using observations to describe and identify patterns. Students are expected to demonstrate understanding that some events (e.g., sunrise and sunset, night and day) are cyclic while others have a beginning and an end.

### **1. Waves: Light and Sound**

Students explore basic properties of light and sound. Students conduct investigations to determine causes and effects. Students apply scientific knowledge, using the properties of light and sound, to solve a problem. This topic creates a foundation for the fourth grade topic of waves in which students examine properties of waves, how waves interact with objects, and how those interactions can be used to communicate information. Students are expected to demonstrate understanding of basic properties of light and sound.



## **Second Grade Storylines**

Students in second grade focus on examining how cause and effect relationships influence change within systems. The focus on systems at this level is conceptual. Students observe pushes and pulls, how water changes the shape of land, changes in the environment, and physical changes in matter. This provides the foundation for understanding how stability affects systems in third grade.

### **2. Forces and Interactions: Pushes and Pulls**

Students investigate the effect of pushes and pulls on the motion of objects. Students examine the relationship between motion and pushes and pulls; and, the relationship between motion and friction. This topic lends itself to conducting investigations on the effect of pushes and pulls on motion, and the relationship between friction and heat. Students extend their understanding of engineering by defining a problem involving friction and developing solutions. This topic provides a foundation for later discussions of forces and interactions, as well as energy. Students are expected to demonstrate understanding that pushes or pulls produce changes in motion, and that objects in contact with each other can produce friction when they move.

### **2. Earth's Surface Systems: Processes that Shape the Earth**

Earth's changing surface and how its surface provides homes for living things is addressed in second grade. This topic builds on kindergarten understanding of needs of plants and animals and where they live and supports later learning in fifth grade when students use fair tests to investigate the effect of different variables on the rate and extent of erosion. This topic lends itself to developing and using models for comparison, investigating and developing explanations from observations, and the crosscutting concept of cause and effect. Students understand the effect that changes to land can have on living things and the problems that this creates. Students develop solutions to these problems building upon design knowledge gained in first grade using the design process. Students are expected to demonstrate understanding of how the shape of land is changed over time and how landforms and bodies of water on Earth's surface provide homes for living things.

### **2. Interdependent Relationships in Ecosystems**

Students study the interdependence of organisms and their surroundings. This topic builds on the kindergarten understanding of the needs of plants and animals, and provides a foundation for understanding of how changes in the environment can affect the types of organisms that live in an area in third grade, as well as interactions in ecosystems in fifth grade. This topic lends itself to defining problems and designing solutions to develop understanding of science concepts. The crosscutting concept of stability and change is highlighted in a life science context and the concept of systems is further developed. Students are expected to demonstrate understanding of the many types of plants and animals that live in, depend on, and meet their needs in particular places in a variety of areas.

### **2. Structure and Properties of Matter**

Students explore measurements of, and changes in, the physical properties of matter. This topic builds on kindergarten understanding of the observable properties of materials and supports later learning of chemical and physical changes and the conservation of weight in fifth grade. This topic lends itself to the use of mathematics, among other practices, as students measure properties of

matter and analyze data. The crosscutting concept of energy and matter only addresses matter, and creates a foundational understanding for later understanding of the particle nature of matter. Students build on their engineering knowledge by testing and analyzing data, which will progress to students testing their own designs. Students are expected to demonstrate their abilities to use data to understand the properties of matter and apply their knowledge to real world problems.



## **Third Grade Story Lines**

Third grade students focus on a conceptual understanding of natural and designed systems by defining their components and on the influence of cause and effect relationships on the stability of system components. Students explore cause and effect relationships effecting organisms, motion, and weather. This builds a foundation for energy flows and cycles effect on systems in fourth and fifth grades.

### **3. Interdependent Relationships in Ecosystems: Environmental Impacts on Organisms**

The impact of changes in the environment on organisms is addressed in third grade. This topic builds on second grade understanding of the dependence of organisms on their surroundings, and is a foundation for learning about healthy ecosystems in fifth grade as well as adaptation and natural selection in middle school. This topic lends itself to the practice of analyzing and interpreting data and the crosscutting concept of stability and change. Students apply knowledge of science concepts to an engineering design problem. Students are expected to demonstrate understanding of ways that changes in the environment can affect the organisms that live in an area, and that the types of plants and animals living on Earth now is different from those that lived long ago.

### **3. Inheritance and Variation of Traits: Life Cycles and Traits**

Students study the traits of organisms. This topic builds on first grade understanding of the similarities and differences among individuals of the same type, and provides a foundation for the study of inheritance and adaptation in middle school. This topic lends itself to using evidence to construct and support explanations and provides further opportunities to develop the crosscutting concept of patterns. Students extend their understanding of engineering by noting that people design technology to meet their needs based on the characteristics of organisms. Students are expected to demonstrate understanding that traits are inherited and/or affected by interactions with the environment, organisms have variations in their inherited traits, and sometimes these variations provide benefits in surviving, finding mates, and reproducing.

### **3. Forces and Interactions**

Students investigate the effect of contact and non-contact forces on the motion of objects. This topic builds on second grade understanding of pushes and pulls and friction. Students learn the scientific use of the word “force” and add noncontact forces to the list of forces. This topic lends itself to conducting investigations to understand balance and unbalanced forces as well as noncontact forces. Students not only design, but also refine a solution to a problem – a key feature of engineering. These experiences form the foundation for later discussions of force, motion, and energy. Students are expected to demonstrate understanding that forces can produce changes in motion if the force is unbalanced and that objects not in contact with each other can produce forces on each other.

### **3. Weather and Climate**

Students understanding of weather and climate builds on kindergarten understanding of the patterns and variations in local weather and its effect on their lives to support understanding of the long term patterns and variations of weather and climate. In addition, this understanding provides a foundation for expansion into using models to explain interactions that affect weather and climate in middle school. This topic lends itself to the use of mathematical thinking, among other practices, to analyze data and compare designed solutions. Third grade students are extending their understanding of

engineering by using their scientific knowledge to evaluate design solutions and communicate about technologies that meet the needs of people interacting with weather-related hazards. Students are expected to demonstrate understanding of the differences between weather and climate and how technology has improved the ability to minimize damage due to weather-related hazards.

## **Fourth Grade Story Lines**

Fourth grade students focus on the effects of matter and energy flows and cycles on the natural and designed world. Students continue to explore systems conceptually in preparation for fifth grade where a more explicit understanding of systems is expected. Students develop a conceptual definition of energy and begin to conceptualize that all matter has energy. Students explore how matter and energy flows and cycles and they use that knowledge to demonstrate understanding of waves, erosion, and weathering.

### **4. Structure, Function, and Information Processing**

Internal structures in plants and animals and connections between types of information from the environment and particular body structures are addressed in fourth grade. This topic builds on and extends first grade understanding of external structures, and provides a foundation for understanding the functions and interactions of body systems in middle school. This topic supports a deeper understanding of models, and provides opportunities for careful investigation and data collection. This topic lends itself to further development of the crosscutting concept of structure and function. Students extend their understanding of criteria and constraints in engineering by comparing different solutions to a problem. Students are expected to demonstrate understanding that plants and animals have both internal and external structures that function to help them respond to their environment, meet their needs, and survive.

### **4. Waves**

Students study waves and how they can be used to transmit information. Students have had experience with light and sound, motion, and energy (the concepts in 4.E are required for one of the performance expectations in 4.W). Students extend these ideas to a scientific examination of the properties of waves, how they interact with objects, and how those interactions can be used to communicate information. This topic lends itself to developing models of waves and their interactions. Students extend their understanding of engineering and the impact of technology on people's lives as they consider the impact of communication technologies. These experiences lay the foundation for a more extensive and mathematical description of waves and their properties in middle school. Students are expected to demonstrate understanding of waves and how they can be used to transmit information.

### **4. Earth's Surface Systems: Processes that Shape the Earth**

Earth's changing surface builds on second grade understanding of how wind and water move materials to change landforms and supports later learning in fifth grade when students use models to describe interactions between the geosphere, hydrosphere, atmosphere, and biosphere. This topic also lends itself to using fair tests to do investigations that control variables and identifying evidence that supports explanations. In addition, it provides further opportunities to develop the crosscutting concept of patterns and cause and effect. Students extend their understanding of science concepts by applying them to engineering design – constructing and testing a design solution to mitigate the effects of a natural hazard. Students are expected to demonstrate understanding of the processes that shape Earth's surface and identify the evidence that supports an explanation for the changes over time.

### **4. Energy**

Students develop a rudimentary understanding about energy. While the word is in common use, students begin to think of energy in scientific terms, building on previous experiences around force and

motion, light, heat, and sound. This topic lends itself to developing models to organize evidence and to construct and support explanations, and introduces and adds the concept of energy to the crosscutting concept of energy and matter. Students extend their understanding of engineering by learning about how people have designed technologies to store, transport, and transform energy to power our civilization, and they learn how engineers address constraints and criteria as they design, test and refine their own device. Students are expected to have an operational definition of energy, and recognize it in a range of forms, such as a motion, heat, light, sound, and electric current.

## **Fifth Grade Story Lines**

Fifth grade students focus on connecting matter and energy flows and cycles to their effect on systems of different scales. Students develop concrete foundational knowledge regarding earth, space, ecological, physical, and technological systems. Students explore cycles of the Earth, moon, and sun. Students consider how matter and energy cycle between all the systems on Earth and how matter is cycled through an ecosystem.

### **5. Space Systems**

Understanding of celestial patterns, including constellations, the phases of the moon, and the role of engineering technology in their observation are addressed in fifth grade. This topic builds on the foundational knowledge gained through the exploration of patterns and cycles in first grade and supports later learning in middle school when students use models to extend their knowledge of patterns to eclipses and tides. This topic lends itself to using models to describe patterns and phenomena. Students consider concepts of scale and proportion as they provide evidence to support the idea that the sun is a star, only much closer to Earth than other stars. Students build on their knowledge of using tools to observe things in greater detail to applying the knowledge of how tools work to design their own tool to enhance vision. Students use data and models to describe celestial patterns and patterns observed on Earth as a result of the relative positions and motion of the sun, Earth, and moon. Students are expected to demonstrate understanding of how technology has improved the ability to explore the universe.

### **5. Earth's Surface Systems**

Earth's major systems builds on understandings of interactions developed in second and fourth grades and supports the middle school topics of Earth's surface processes, as well as weather and climate systems. This topic lends itself to using models to describe interactions of a natural system while identifying the limitations of the models used and further develops the crosscutting concept of systems. Students extend their understanding of engineering, designing, and evaluating solutions to environmental problems that decrease risks, increase benefits, or meet societal demands. Students are expected to demonstrate understanding of how systems interact in multiple ways shaping land, influencing weather and climate, and how human activities affect these systems and interactions.

### **5. Matter and Energy in Organisms and Ecosystems**

The transfer of matter in ecosystems is addressed in fifth grade. This topic builds on second grade understanding of the dependence of organisms on their surroundings and supports middle school understanding of photosynthesis, the cycling and conservation of matter, and the flow of energy. This standard lends itself to developing and using models, and has a strong emphasis on the crosscutting concept of matter and energy. Students are expected to demonstrate understanding of the transfer of matter among organisms in food webs and between organisms and their environment, and the role of the sun in providing energy to organisms.

### **5. Structure and Properties of Matter**

Students study the changes of matter and the conservation of total weight in the system. This topic builds on second grade understanding of measuring physical properties of and changes in matter and supports later learning of the atomic theory of matter in middle school. Students form a strong foundation for middle school structures and properties of matter. This topic lends itself to the





crosscutting concept of matter and energy and to the practice of modeling, making abstract concepts such as particles too small to see more concrete. Students are expected to apply knowledge of physical and chemical changes to design a solution.

## How to Read the *Next Generation Science Standards (NGSS)*

The Next Generation Science Standards (NGSS) are distinct from prior science standards in that they integrate three dimensions within each standard and have intentional connections across standards. To provide guidance and clarification to all users of the standards, the writers have created a System Architecture that highlights the NGSS as well as each of the three integral dimensions and connections to other grade bands and subjects. The standards are organized in a table with three main sections:

- 1) Performance expectation(s)
- 2) The foundation boxes, and
- 3) The connection boxes

### Reading the Elements of the System Architecture

In the figure below, from top to bottom are seen the title, the topic label row, the performance expectation(s) (the assessable component), the foundation boxes (containing Practices, Disciplinary Core Ideas and Crosscutting Concepts), and the connection boxes.

Code for Topic Name	
System Architecture	
Assessable Component	<b>MS.ESS-SS Space Systems</b> Students who demonstrate understanding can: a. <b>Construct explanations for the occurrences of day/night cycles, seasons, tides, eclipses, and lunar phases based on patterns of the observed motions of celestial bodies.</b> [Assessment Boundary: Kepler's Laws of orbital motion are not used as the basis for evidence at this level.] b. <b>Obtain, evaluate, and communicate support the Big Bang theory.</b> [Clarification: radiation, the motions of galaxies away from each other.] c. <b>Construct and use models to describe the solar system, Milky Way Galaxy, and universe.</b> [Assessment Boundary: Mathematical models are not expected; use AU for Solar System scale; use light years for universal scale.] d. <b>Use models to support explanations of the composition, structure, and formation of the solar system from a disk of dust and gas drawn together by gravity.</b> The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> .
	<div> <div> <b>Science and Engineering Practices</b>            Developing and Using Models            Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to explain, explore, and predict more abstract phenomena and design systems.            Use and/or construct models to predict, explain, and/or collect data to test ideas about phenomena in natural or designed systems, and represent inputs and output. (c), (d)            Constructing Solutions            Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence, principles, and knowledge.            Lowercase letters designate which of the performance expectations use this practice.            Obtaining Information            Obtaining, evaluating, and communicating information in 6-8 builds on 3-5 and progresses to evaluate the merit and validity of ideas and methods.            Read critically using scientific knowledge and reasoning to evaluate data, hypotheses, conclusions, and competing information. (b)         </div> <div> <b>Disciplinary Core Ideas</b>            ESS1.A: The Universe and Its Stars            Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (a)            The universe began with a period of extreme and rapid expansion known as the Big Bang. Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. (b)            Earth and the solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (c)            ESS1.B: Earth and the Solar System            The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids. Gravity has formed together by the sun by its gravity. (a)            This model of eclipses of motions of the sun by its gravity. (a)            Earth's spin (short-term) but tilted relative to its orbit around the sun; the differential intensity of sunlight on different areas of Earth over the year is a result of that tilt, as are the seasons that result. (a)            PS2.C: Stability and Instability in Physical Systems            A system can be changing but have a stable repeating cycle of changes; such observed regular patterns allow predictions about the system's future (e.g., Earth orbiting the sun). (a)         </div> <div> <b>Crosscutting Concepts</b>            Patterns            Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. Graphs and charts can be used to identify patterns in data. (a), (b)            Scale, Proportion, and Quantity            Time, space, and energy phenomena can be observed at various scales using models to study systems that are observed at different scales. (a)            Lowercase letters designate which of the performance expectations incorporate this crosscutting concept.         </div> </div>
Foundation Boxes	Connections to other DCIs in this grade-level: <b>MS.LS-GOR, MS.PS-FM, MS.PS-IF, MS.PS-E</b> Articulation to DCIs across grade-levels: <b>1.PCS, S.SSS, MS.ESS-SS</b> Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases] ELA W.6.1 Write arguments to support claims with clear reasons and relevant evidence. W.6.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. W.7.1 Write arguments to support claims with clear reasons and relevant evidence. W.7.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details and examples; use appropriate eye contact, adequate volume, and clear pronunciation. W.8.1 Write arguments to support claims with clear reasons and relevant evidence. W.8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
	<b>Mathematics</b> MP.4 Model with mathematics B.F Use functions to model relationships between quantities
Connections Boxes	

A detailed explanation of the elements of the System Architecture follows:

1. Performance Expectations

The standards are written as student performance expectations. These statements each incorporate a practice, a disciplinary core idea, and a crosscutting concept. The performance expectations are the assessable components of the NGSS architecture identified with lowercase letters, and each combines Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The performance expectations were initially written in topical groupings, but can also be viewed independently. Topical groupings of performance expectations do not imply a preferred ordering for instruction—nor should all performance expectations under one topic necessarily be taught in one course. There are two additional statements associated with the performance expectations that are meant to render additional support and clarity:

- a. *Assessment Boundary Statements* are included with individual performance expectations where appropriate, to provide further guidance or to specify the scope of the expectation at a particular grade level.
- b. *Clarification Statements* are designed to supply examples or additional clarification to the performance expectations.

2. Foundation Boxes

Foundation boxes provide additional information, expanding and explaining the performance expectations in relation to the three dimensions: Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts. Each statement in any one of the three foundation boxes is coded to the performance expectation(s) that embody it by a lowercase letter in parentheses.

- a. *Science and Engineering Practice Statements*: These statements are derived from and grouped by the eight categories detailed in the *Framework* to further explain the science and engineering practices important to emphasize in each grade band. Most topical groupings of performance expectations emphasize only a few of the practice categories; however, all practices are emphasized within a grade band. Teachers should be encouraged to utilize several practices in any instruction. The purpose is to demonstrate the specific practice for which students will be held accountable.
- b. *Disciplinary Core Ideas (DCIs)*: These statements are taken verbatim from the *Framework*, and detail the sub supporting ideas necessary for student mastery of the core idea.
- c. *Crosscutting Concept Statements*: These statements were derived from the *Framework* to further explain the crosscutting concepts important to emphasize in each grade band. The crosscutting concepts are grouped by the categories detailed in the *Framework*. Most topical groupings of performance expectations emphasize only a few of the crosscutting concept categories, however all are emphasized within a grade band. Again, the list is not exhaustive nor is it intended to limit instruction.

3. Connection Boxes

- a. *Connections to other DCIs in this grade level*: This box will contain the names of science topics in other disciplines that have corresponding disciplinary core ideas at the same grade level. For example, both Physical Science and Life Science standards contain core ideas related to Photosynthesis, and could be taught in relation to one

another. As the standards move toward completion, this box will provide links to specific performance expectations.

- b. *Articulation of DCIs across grade levels:* This box will contain the names of other science topics that either 1) provide a foundation for student understanding of the core ideas in this standard (usually standards at prior grade levels) or 2) build on the foundation provided by the core ideas in this standard (usually standards at subsequent grade levels). As the standards move toward completion, this box will provide links to specific performance expectations.
- c. *Connections to the Common Core State Standards:* This box will contain the coding and names of Common Core State Standards in English Language Arts & and Literacy and Mathematics that align to the performance expectations. For example, performance expectations that require student use of exponential notation will align to the corresponding CCSS mathematics standards.

#### Color Coding

Online versions of the standards display color coding of the words within each standard statement. The colors represent the three dimensions: blue for Science and Engineering Practices, orange for Disciplinary Core Ideas, and green for Crosscutting Concepts. Clarification Statements and Assessment Boundaries are red. Printed versions of the standards do not have color coding of the three dimensions; in these cases the coding for the three dimensions will be accomplished through the lowercase letters found after each foundation box statement.



## 5. Matter and Energy in Organisms and Ecosystems

### 5. Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

**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.** [Clarification Statement: Examples of models could include diagrams, and flow charts.]

**5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.** [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

**5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.** [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

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

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<p><b>Developing and Using Models</b> Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.</p> <ul style="list-style-type: none"> <li>Use models to describe phenomena. (5-PS3-1)</li> <li>Develop a model to describe phenomena. (5-LS2-1)</li> </ul> <p><b>Engaging in Argument from Evidence</b> Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).</p> <ul style="list-style-type: none"> <li>Support an argument with evidence, data, or a model. (5-LS1-1)</li> </ul> <p style="text-align: center;"><b>Connections to Nature of Science</b></p> <p><b>Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</b></p> <ul style="list-style-type: none"> <li>Science explanations describe the mechanisms for natural events. (5-LS2-1)</li> </ul>	<p><b>PS3.D: Energy in Chemical Processes and Everyday Life</b></p> <ul style="list-style-type: none"> <li>The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (5-PS3-1)</li> </ul> <p><b>LS1.C: Organization for Matter and Energy Flow in Organisms</b></p> <ul style="list-style-type: none"> <li>Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (<i>secondary to 5-PS3-1</i>)</li> <li>Plants acquire their material for growth chiefly from air and water. (5-LS1-1)</li> </ul> <p><b>LS2.A: Interdependent Relationships in Ecosystems</b></p> <ul style="list-style-type: none"> <li>The food of almost any kind of 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. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as “decomposers.” Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)</li> </ul> <p><b>LS2.B: Cycles of Matter and Energy Transfer in Ecosystems</b></p> <ul style="list-style-type: none"> <li>Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (5-LS2-1)</li> </ul>	<p><b>Systems and System Models</b></p> <ul style="list-style-type: none"> <li>A system can be described in terms of its components and their interactions. (5-LS2-1)</li> </ul> <p><b>Energy and Matter</b></p> <ul style="list-style-type: none"> <li>Matter is transported into, out of, and within systems. (5-LS1-1)</li> <li>Energy can be transferred in various ways and between objects. (5-PS3-1)</li> </ul>
<p><b>Connections to other DCIs in fifth grade:</b> <b>5.PS1.A</b> (5-LS1-1),(5-LS2-1); <b>5.ESS2.A</b> (5-LS2-1)</p> <p><b>Articulation of DCIs across grade-levels:</b> <b>K.LS1.C</b> (5-PS3-1),(5-LS1-1); <b>2.PS1.A</b> (5-LS2-1); <b>2.LS2.A</b> (5-PS3-1),(5-LS1-1); <b>2.LS4.D</b> (5-LS2-1); <b>4.PS3.A</b> (5-PS3-1); <b>4.PS3.B</b> (5-PS3-1); <b>4.PS3.D</b> (5-PS3-1); <b>4.ESS2.E</b> (5-LS2-1); <b>MS.PS3.D</b> (5-PS3-1),(5-LS2-1); <b>MS.PS4.B</b> (5-PS3-1); <b>MS.LS1.C</b> (5-PS3-1),(5-LS1-1),(5-LS2-1); <b>MS.LS2.A</b> (5-LS2-1); <b>MS.LS2.B</b> (5-PS3-1),(5-LS2-1)</p> <p><b>Common Core State Standards Connections:</b></p> <p><b>ELA/Literacy –</b></p> <p><b>RI.5.1</b> Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. (5-LS1-1)</p> <p><b>RI.5.7</b> Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-PS3-1),(5-LS2-1)</p> <p><b>RI.5.9</b> Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1)</p> <p><b>W.5.1</b> Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1)</p> <p><b>SL.5.5</b> Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-PS3-1),(5-LS2-1)</p> <p><b>Mathematics –</b></p> <p><b>MP.2</b> Reason abstractly and quantitatively. (5-LS1-1),(5-LS2-1)</p> <p><b>MP.4</b> Model with mathematics. (5-LS1-1),(5-LS2-1)</p> <p><b>MP.5</b> Use appropriate tools strategically. (5-LS1-1)</p> <p><b>5.MD.A.1</b> Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. (5-LS1-1)</p>		

\*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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# Verbs Based on the Revised Bloom's Taxonomy

Remembering	Understanding	Applying
alphabetize	account for	illustrate
check	advance	implement
count	alter	interpret
define	annotate	make
draw	associate	manipulate
duplicate	calculate	map
fill in the blank	classify	mobilize
find	construe	operate
hold	contrive	practice
identify	convert	put in
know	describe	put to use
label	discuss	relate
list	estimate	schedule
locate	expand	show
match	explain	sketch
memorize	expound	solve
name	express	teach
offer	identify	use
omit	infer	utilize
pick	interpret	wield
	locate	write
	moderate	
	offer	
	order	adopt
	outline	apply
	paraphrase	calculate
	predict	capitalize
	project	chart
	propose	choose
	qualify	complete
	recognize	compute
	rephrase	conclude
	report	conduct
	restate	consume
	retell	demonstrate
	review	determine
	reword	dramatize
	rewrite	draw
	select	employ
	spell out	exercise
	submit	exert
	substitute	exploit
	summarize	generate
	transform	handle
	translate	
	vary	

Analyzing	Evaluating	Creating
analyze appraise audit break down categorize check classify compare contrast criticize debate deduct detect diagnose diagram differentiate discriminate dissect distinguish divide	arbitrate appraise argue assess choose compare conclude critique decide defend determine editorialize evaluate give opinion grade  judge justify measure prioritize rank rate recommend resolve score select support value verify weigh alternatives	arrange assemble build change combine compile compose conceive conceptualize construct create design develop devise forecast formulate generalize generate hypothesize imagine integrate  invent manage organize originate plan predict prepare prescribe pretend produce propose rearrange reconstruct reorder reorganize role play structure suppose synthesize visualize write

**FIGURE 5.12**

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