Putting Practices in Place

Summer 2015

Participant Handouts

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

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

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop a model to describe phenomena. (MS-LS2-3)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Constructing Explanations and Designing 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 consistent with scientific ideas, principles, and theories.
- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems
- Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS-LS2-1)
- In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS-LS2-1)
- Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)
- Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary to MS-LS2-5)*

ETS1.B: Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary to MS-LS2-5)*

Crosscutting Concepts

Patterns
- Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Cause and Effect
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

Science Addresses Questions About the Natural and Material World
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS2-3); **MS.LS1.B** (MS-LS2-2); **MS.LS4.C** (MS-LS2-4); **MS.LS4.D** (MS-LS2-4); **MS.ESS2.A** (MS-LS2-3),(MS-LS2-4); **MS.ESS3.A** (MS-LS2-1),(MS-LS2-4); **MS.ESS3.C** (MS-LS2-1),(MS-LS2-4),(MS-LS2-5)

Articulation across grade-bands: **1.LS1.B** (MS-LS2-2); **3.LS2.C** (MS-LS2-1),(MS-LS2-4); **3.LS4.D** (MS-LS2-1),(MS-LS2-4); **5.LS2.A** (MS-LS2-1),(MS-LS2-3); **5.LS2.B** (MS-LS2-3); **HS.PS3.B** (MS-LS2-3); **HS.LS1.C** (MS-LS2-3); **HS.LS2.A** (MS-LS2-1),(MS-LS2-2),(MS-LS2-5); **HS.LS2.B** (MS-LS2-2),(MS-LS2-3); **HS.LS2.C** (MS-LS2-4),(MS-LS2-5); **HS.LS2.D** (MS-LS2-2); **HS.LS4.C** (MS-LS2-1),(MS-LS2-4); **HS.LS4.D** (MS-LS2-1),(MS-LS2-4),(MS-LS2-5); **HS.ESS2.A** (MS-LS2-3); **HS.ESS2.E** (MS-LS2-4); **HS.ESS3.A** (MS-LS2-1),(MS-LS2-5);

Putting Practices into Place: Resources

What You Can Do Now:

- **Read:** *"A Framework for K-12 Science Education"* available at nap.edu
- **Visit:** Nextgenscience.org and become familiar with the NGSS performance expectations. Review the appendices.
- **Watch:** NSTA Webinar Series on NGSS and Bozeman Science Videos created by Paul Anderson.
- **Attend:** Professional development targeted at understanding NGSS.
- **Modify:** Current classroom lessons to include NGSS science and engineering practices and cross cutting concepts; encourage student independence and problem solving; use science notebooks to increase student thinking.

Resource Links:

ADE Science Webpage:

NGSS Webmix: **http://www.symbaloo.com/mix/ngssresources1** (Symbaloo is a free site. This webmix can be bookmarked or added to your own Symbaloo page after you register. The mix contains direct links to the resources listed below and many others.)

Next Generation Science Standards: http://nextgenscience.org/

"A Framework for K-12 Science Education": The book can be downloaded free of charge at: http://www.nap.edu/catalog.php?record_id=13165

NSTA Webinar Series on NGSS:
http://learningcenter.nsta.org/products/symposia_seminars/Ngss/webseminar.aspx

Bozeman Science Videos: http://www.bozemanscience.com/

Teaching Shifts: http://www.k12center.org/rsc/pdf/reiser.pdf

Models and Modeling, an Introduction: From Ambitious Science Teaching, an explanation of modeling and sample student work. http://ambitiousscienceteaching.org/wp-content/uploads/2014/09/Models-and-Modeling-An-Introduction1.pdf

Questions on NGSS Architecture

1. What does it mean when we say that Next Generation Science Standards has three dimensions?

2. What do the colors represent in the foundation boxes?

3. What does the red text below the Performance Expectation mean?

4. Where are the connections to Common Core Science Standards in Math and English Language Arts?

5. Which Science and Engineering Practices are embedded in these Performance Expectations?

Navigating the ADE Science Website

1. In the working documents link: What is the name of Appendix D?

2. After clicking on the link to Appendix D: What happened in January 2013?

3. Find the Arkansas K-12 Science Standards Timeline link: What is scheduled to occur in fall of 2017?

4. Find the Arkansas Science Assessments link: Who is the contact person for Student Assessment?

Exploring the Next Generation Science Website

Navigate to this link: www.nextgenscience.org
Click: 'Explore the NGSS'

Each table group will focus on one question below and demonstrate what they learn to participants.

1. Click: 'View the NGSS in Disciplinary Core Idea (DCI) Arrangements'. List the four main strands of the standards that fourth grade will cover.

2. Click: 'View the NGSS in Topic Arrangements'. What is the difference between Middle School and High School Earth and Space Sciences?

3. Click: 'View and Search the NGSS performance expectations individually': What four search options are available?

4. Refer to the 'NGSS Appendices' column on the left. Click: Appendix F 'Science and Engineering Practices': What are the 8 practices listed?

Topsy-Turvy Test Tubes
Student Sheet

Materials:

2-25 mm test tubes or small clear glasses
1 coffee filter: small size/cut in half

2 rubber bands	clear household ammonia
water	Pipette
Phenolphthalein(in original container)	Test tube rack
Safety goggles	Apron
Gloves	SDS Ammonia
SDS phenolphthalein	colored pencils
scissors	ruler

Safety Precautions: Please refer to the SDS for ammonia and phenolphthalein.

Goggles, Aprons, and Gloves MUST be worn at ALL TIMES!!

Please read all procedures before you begin setting up this investigation. If you have questions, please ask your facilitator before you begin.

Procedure:

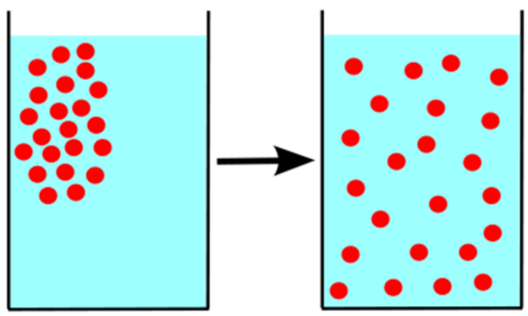
1. Place 5 drops of phenolphthalein in one large test tube and fill it with water, leaving approximately 2.5 cm at the top.
2. Cut a coffee filter in half. Fold each filter piece in half.
3. Using one piece of the filter, cover the opening of the water-filled tube and secure with a rubber band.
4. Fill the **second test tube** with ammonia, leaving approximately 2.5 cm at the top. Cover the opening of the test tube with the other folded coffee filter and secure it with a rubber band.
5. Place the **ammonia tube** in the test tube rack. Balance the water-filled tube **upside-down** over the ammonia tube. The top water filled tube should balance on the bottom ammonia filled tube.

Turn to page 5 in your participant's SCIENCE Notebook. Predict what you think is going to happen and record with a drawing and a written explanation.

On page 6 in your participant's SCIENCE Notebook, make drawings of your observations as you conduct the investigation.

Diffusion and Osmosis

Have you ever walked by the food court at the local mall and had your senses assailed by the smell of foods from around the world? Have you stayed in a swimming pool too long and emerged with skin pale and wrinkled or dropped food coloring into water and watched it quickly disperse throughout the container?

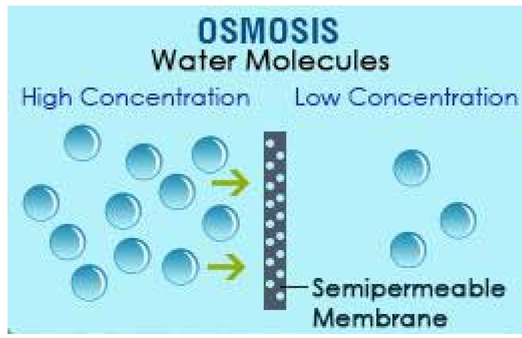


All of these are examples of the scientific process known as diffusion. Diffusion is the movement of molecules from a region of high concentration to a region of low concentration. The word diffusion itself means to "spread out." In the illustration above, molecules of a material are concentrated in the upper-left corner of the container. Because there is a high concentration of the molecules, the energy within the molecules began to disperse them throughout the area of lower concentration, as shown on the right.

First described by the scientist Robert Brown in 1827, diffusion might be viewed as the random 'walk' of small particles in suspension to regions of lower concentration. His observations of the movement of these particles are described as **Brownian movement** and can be demonstrated by the movement of the food coloring and water example above. Simply stated, the Brownian theory of motion states that materials are composed of atoms or molecules in constant motion that are constantly colliding with each other. When materials of different concentrations are combined, the resulting collusions occur until the materials are dispersed uniformly throughout the container.

The rate of diffusion is greatly influenced by other factors including temperature, density, and convection currents.

Osmosis is a special kind of diffusion in which **solvent** molecules move from a region of higher concentration to a lower concentration across a **semipermeable membrane**. The solution that has more solute concentration than the surrounding is said to be **hypertonic** while the solution with lower solute is said to be **hypotonic**. Osmosis takes place when water molecules move from a hypotonic to a hypertonic solution. The semipermeable membrane is selective to the smaller solvent molecules and not to the larger solute molecules. This process is essential to life in maintaining water balance.



Osmosis and diffusion are similar processes in that both involve transport of molecules based on concentration differences. Both involve passive transport of materials and do not require any external energy to drive the process. The primary difference is that diffusion does not require a semipermeable membrane be present for the movement of molecules.

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A Science Framework for K-12 Science Education provides the blueprint for developing the *Next Generation Science Standards* (NGSS). The *Framework* expresses a vision in science education that requires students to operate at the nexus of three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The *Framework* identified a small number of disciplinary core ideas that all students should learn with increasing depth and sophistication, from Kindergarten through grade twelve. Key to the vision expressed in the *Framework* is for students to learn these disciplinary core ideas in the context of science and engineering practices. The importance of combining science and engineering practices and disciplinary core ideas is stated in the *Framework* as follows:

> *Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content.* (NRC *Framework*, 2012, p. 218)

The *Framework* specifies that each performance expectation must combine a relevant practice of science or engineering, with a core disciplinary idea and crosscutting concept, appropriate for students of the designated grade level. That guideline is perhaps the most significant way in which the NGSS differs from prior standards documents. In the future, science assessments will not assess students' understanding of core ideas separately from their abilities to use the practices of science and engineering. They will be assessed together, showing students not only "know" science concepts; but also, students can use their understanding to investigate the natural world through the practices of science inquiry, or solve meaningful problems through the practices of engineering design. The *Framework* uses the term "practices," rather than "science processes" or "inquiry" skills for a specific reason:

> *We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice.* (NRC *Framework*, 2012, p. 30)

The eight practices of science and engineering that the *Framework* identifies as essential for all students to learn and describes in detail are listed below:

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

Rationale

Chapter 3 of the *Framework* describes each of the eight practices of science and engineering and presents the following rationale for why they are essential.

> *Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices also*

helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview.

The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor—one that has deeply affected the world they live in. Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food, and addressing climate change.

Any education that focuses predominantly on the detailed products of scientific labor—the facts of science—without developing an understanding of how those facts were established or that ignores the many important applications of science in the world misrepresents science and marginalizes the importance of engineering. (NRC *Framework* 2012, pp. 42-43)

As suggested in the rationale, above, Chapter 3 derives the eight practices based on an analysis of what professional scientists and engineers do. It is recommended that users of the NGSS read that chapter carefully, as it provides valuable insights into the nature of science and engineering, as well as the connections between these two closely allied fields. The intent of this section of the NGSS appendices is more limited—to describe what each of these eight practices implies about what students can do. Its purpose is to enable readers to better understand the performance expectations. The "Practices Matrix" is included, which lists the specific capabilities included in each practice for each grade band (K-2, 3-5, 6-8, 9-12).

Guiding Principles

The development process of the standards provided insights into science and engineering practices. These insights are shared in the following guiding principles:

Students in grades K-12 should engage in all eight practices over each grade band. All eight practices are accessible at some level to young children; students' abilities to use the practices grow over time. However, the NGSS only identifies the capabilities students are expected to acquire by the end of each grade band (K-2, 3-5, 6-8, and 9-12). Curriculum developers and teachers determine strategies that advance students' abilities to use the practices.

Practices grow in complexity and sophistication across the grades. The *Framework* suggests how students' capabilities to use each of the practices should progress as they mature and engage in science learning. For example, the practice of "planning and carrying out investigations" begins at the kindergarten level with guided situations in which students have assistance in identifying phenomena to be investigated, and how to observe, measure, and record outcomes. By upper elementary school, students should be able to plan their own investigations. The nature of investigations that students should be able to plan and carry out is also expected to increase as students mature, including the complexity of questions to be studied, the ability to determine what kind of investigation is needed to answer different kinds of questions, whether or not variables need to be controlled and if so, which are most important, and at the high school level, how to take measurement error into account. As listed in the tables in this chapter, each of the eight practices has its own progression, from kindergarten to grade 12. While these progressions are derived from Chapter 3 of the *Framework*, they are refined based on experiences in crafting the NGSS and feedback received from reviewers.

Each practice may reflect science or engineering. Each of the eight practices can be used in the service of scientific inquiry or engineering design. The best way to ensure a practice is being used for science or engineering is to ask about the goal of the activity. Is the goal to answer a question? If so, students are doing science. Is the purpose to define and solve a problem? If so, students are doing engineering. Box 3-2 on pages 50-53 of the *Framework* provides a side-by-side comparison of how scientists and engineers use these practices. This chapter briefly summarizes what it "looks like" for a student to use each practice for science or engineering.

Practices represent what students are expected to do, and are not teaching methods or curriculum. The *Framework* occasionally offers suggestions for instruction, such as how a science unit might begin with a scientific investigation, which then leads to the solution of an engineering problem. The NGSS avoids such suggestions since the goal is to describe what students should be able to do, rather than how they should be taught. For example, it was suggested for the NGSS to recommend certain teaching strategies such as using biomimicry—the application of biological features to solve engineering design problems. Although instructional units that make use of biomimicry seem well-aligned with the spirit of the *Framework* to encourage integration of core ideas and practices, biomimicry and similar teaching approaches are more closely related to curriculum and instruction than to assessment. Hence, the decision was made not to include biomimicry in the NGSS.

The eight practices are not separate; they intentionally overlap and interconnect. As explained by Bell, et al. (2012), the eight practices do not operate in isolation. Rather, they tend to unfold sequentially, and even overlap. For example, the practice of "asking questions" may lead to the practice of "modeling" or "planning and carrying out an investigation," which in turn may lead to "analyzing and interpreting data." The practice of "mathematical and computational thinking" may include some aspects of "analyzing and interpreting data." Just as it is important for students to carry out each of the individual practices, it is important for them to see the connections among the eight practices.

Performance expectations focus on some but not all capabilities associated with a practice. The *Framework* identifies a number of features or components of each practice. The practices matrix, described in this section, lists the components of each practice as a bulleted list within each grade band. As the performance expectations were developed, it became clear that it's too much to expect each performance to reflect all components of a given practice. The most appropriate aspect of the practice is identified for each performance expectation.

Engagement in practices is language intensive and requires students to participate in classroom science discourse. The practices offer rich opportunities and demands for language learning while advancing science learning for all students (Lee, Quinn, & Valdés, in press). English language learners, students with disabilities that involve language processing, students with limited literacy development, and students who are speakers of social or regional varieties of English that are generally referred to as "non-Standard English" stand to gain from science learning that involves language-intensive scientific and engineering practices. When supported appropriately, these students are capable of learning science through their emerging language and comprehending and carrying out sophisticated language functions (e.g., arguing from evidence, providing explanations, developing models) using less-than-perfect English. By engaging in such practices, moreover, they simultaneously build on their understanding of science and their language proficiency (i.e., capacity to do more with language).

On the following pages, each of the eight practices is briefly described. Each description ends with a table illustrating the components of the practice that students are expected to master at the end of each grade band. All eight tables comprise the *practices matrix*. During development of the NGSS, the practices matrix was revised several times to reflect improved understanding of how the practices connect with the disciplinary core ideas.

Practice 2 Developing and Using Models

> *Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system.* (NRC Framework, 2012, p. 58)

Models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations. Although models do not correspond exactly to the real world, they bring certain features into focus while obscuring others. All models contain approximations and assumptions that limit the range of validity and predictive power, so it is important for students to recognize their limitations.

In science, models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, to generate data that can be used to make predictions, and to communicate ideas to others. Students can be expected to evaluate and refine models through an iterative cycle of comparing their predictions with the real world and then adjusting them to gain insights into the phenomenon being modeled. As such, models are based upon evidence. When new evidence is uncovered that the models can't explain, models are modified.

In engineering, models may be used to analyze a system to see where or under what conditions flaws might develop, or to test possible solutions to a problem. Models can also be used to visualize and refine a design, to communicate a design's features to others, and as prototypes for testing design performance.

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Distinguish between a model and the actual object, process, and/or events the model represents. • Compare models to identify common features and differences. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). • Develop a simple model based on evidence to represent a proposed object or tool.	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. • Identify limitations of models. • Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. • Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. • Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Evaluate limitations of a model for a proposed object or tool. • Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed. • Use and/or develop a model of simple systems with uncertain and less predictable factors. • Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena. • Develop and/or use a model to predict and/or describe phenomena. • Develop a model to describe unobservable mechanisms. • Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism or system in order to select or revise a model that best fits the evidence or design criteria. • Design a test of a model to ascertain its reliability. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. • Develop a complex model that allows for manipulation and testing of a proposed process or system. • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Practice 6 Constructing Explanations and Designing Solutions

The goal of science is to construct explanations for the causes of phenomena. Students are expected to construct their own explanations, as well as apply standard explanations they learn about from their teachers or reading. The *Framework* states the following about explanation:

> "*The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories*."(NRC Framework, 2012, p. 52)

An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data.

The goal of engineering is to solve problems. Designing solutions to problems is a systematic process that involves defining the problem, then generating, testing, and improving solutions. This practice is described in the *Framework* as follows.

> *Asking students to demonstrate their own understanding of the implications of a scientific idea by developing their own explanations of phenomena, whether based on observations they have made or models they have developed, engages them in an essential part of the process by which conceptual change can occur.*
>
> *In engineering, the goal is a design rather than an explanation. The process of developing a design is iterative and systematic, as is the process of developing an explanation or a theory in science. Engineers' activities, however, have elements that are distinct from those of scientists. These elements include specifying constraints and criteria for desired qualities of the solution, developing a design plan, producing and testing models or prototypes, selecting among alternative design features to optimize the achievement of design criteria, and refining design ideas based on the performance of a prototype or simulation.* (NRC Framework, 2012, p. 68-69)

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. • Generate and/or compare multiple solutions to a problem.	Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation. • Apply scientific ideas to solve design problems. • Generate and compare multiple solutions to a problem based on how	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 consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. • Construct an explanation using models or representations. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. • Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.	Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.

	well they meet the criteria and constraints of the design solution.	• Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. • Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing.	• Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Practice 7 Engaging in Argument from Evidence

> *The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose*. (NRC Framework, 2012, p. 73)

Argumentation is a process for reaching agreements about explanations and design solutions. In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community.

Argument in science goes beyond reaching agreements in explanations and design solutions. Whether investigating a phenomenon, testing a design, or constructing a model to provide a mechanism for an explanation, students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Identify arguments that are supported by evidence. • Distinguish between explanations that account for all gathered evidence and those that do not. • Analyze why some evidence is relevant to a scientific question and some is not. • Distinguish between opinions and evidence in one's own explanations. • Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument. • Construct an argument with evidence to support a claim. • Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.	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). • Compare and refine arguments based on an evaluation of the evidence presented. • Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation. • Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions. • Construct and/or support an argument with evidence, data, and/or a model. • Use data to evaluate claims about cause and effect. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts. • Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail. • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. • Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions. • Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,

		• Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Excerpt from “Models and Modeling: An Introduction” HO7
www.ambitiousscienceteaching.org

Why is Modeling Important?

Modeling is important because models are drawings or diagrams that represent one’s current understandings about how a specific system behaves. In this way, models themselves can be a form of explanation (sometimes we can combine them as ideas by saying we are working on an “explanatory model”). In classroom settings, modeling and explanation are also unique among other practices, in that they don’t just happen on a particular day. Rather, students’ on-going attempts to revise major explanations and models are “stretched across” a whole unit of instruction.

From the past twenty years of research on learning, we know that children make dramatic advances in their understanding of science by generating and revising explanatory models. For both scientists and children, modeling is something done publicly and collaboratively; it organizes and guides many other forms of practice, and importantly it opens up opportunities to reason about ideas, data, arguments, and new questions.

Scientific models are made to be dynamic. Just as science knowledge changes with new discoveries, scientific models have to change too. Scientists often reconstruct models so that they can be useful in explaining a wider range of circumstances. In other words, an improved scientific model is usually consistent with both new and old scientific evidence.
So models serve several important functions in science—they don’t just “represent”, they help groups of scientists generate predictions, construct explanations, show gaps in knowledge, and pose new questions for investigation. Models can be used to produce new understandings or to communicate understandings to others—and are often used for both purposes at the same time.

Use of Models in the Classroom

Models are used very narrowly by most teachers and they are often employed simply to illustrate science ideas. They are used as props to show, point out, or provide examples of a system or phenomenon. Even when teachers ask students to draw out their own understandings in the forms of pictures or diagrams, such displays are disconnected from knowledge-building activities—students simply create posters of science ideas that can already be found in textbooks, like the water cycle or the steps in mitosis. One could say this is “using models”, but these experiences don't support learning very well, in part because they don’t require students to solve problems situated in everyday circumstances, to develop ideas or to make connections among ideas.

The more rigorous work that scientists and students can do is to construct, test, evaluate, and revise models. It is during these kinds of work that students see the need to learn new science ideas, to reason about how ideas and events are related, to argue about evidence, and to monitor their own thinking along the way. This is the work of modeling and these are the activities that build knowledge.

Sample Lesson Summaries HO8

Lesson A. Building a Model DNA

(adapted from Assignment Discovery Online Curriculum)

To help students understand how the components of DNA fit together, each student will make a model of DNA out of pipe-cleaners, dried pasta, and fishing line.
Explain to students that the pinwheel pasta represents the sugar component, the ziti pasta represents the phosphate, and the colored pipe cleaners represent the bases. Instruct them to start with the pinwheel pasta and alternate with the ziti pasta as they thread the pasta on the line. After the pasta has been strung on both lines, each line should have a total of 17 alternating pasta pieces. They will then choose a different colored pipe cleaner for each base and will create base pairs by twisting the pipe cleaners together. The DNA "ladder" can then be made by using the pasta lines as the sides and the twisted pipe cleaners as the steps.
The resulting model can be used when discussing the structure and function of DNA.

Lesson B. Bridge-Building

(Adapted from www.scholastic.com)

Students will view a short PowerPoint that includes pictures of various kinds of bridges. They will then be given the pictures on small cards and asked to sort them into the 4 categories of bridges: beam, truss, arch and suspension. Once students have sorted them correctly, they will then be given the supplies to build model bridges.

Students will need to build a small model for each kind of bridge: beam, truss, arch and suspension. The models will be made from Popsicle sticks, glue, tape, string and clay.
Students will create a poster that: explains the differences and similarities in each bridge, shows examples of famous bridges of each kind, and lists the strengths and weaknesses of each kind of bridge.

Lesson C. Tasty Models

(adapted from Scientific American)

Atomic representations can be used to show the arrangement of nuclei and bond types. Understanding this arrangement of atoms within nutrient molecules helps explain their chemical behavior, health attributes and role in weight balance. In this activity, students construct several different molecular models that represent carbohydrates, proteins, nucleic acids and fats, as well as bonding processes such as dehydration.

Students will use ball and stick models to create models of various molecules that are listed on their worksheet. The supplies in the kit are color-coded so that students know which color ball represents each atom. Each bond is also distinguished in the pictures of molecules.
Students will need to complete a total of 17 different models and will need to take a picture of each with their phone or flip camera. The resulting pictures need to be labeled and compiled in one document by each student. They will need to be emailed to the teacher for homework credit.

Lesson D. Filtration Investigation
(adapted from www.tryengineering.com)

Students will work in groups to research and design a filtration system that is economical and effective enough to be used on a large scale. They will create models of their system and will try it out on samples of contaminated water (provided by the teacher). Each group will need to collect data on how well their system removes physical, chemical and biological contaminants.

- Methods for testing the effectiveness of the system can include (but are not limited to) Vernier labware and probes, LaMotte water testing kits, and bacteria cultures, agar and Petri dishes.
- Each group will be responsible for maintaining records of the development of their filtration system, data collection and analysis on its effectiveness, and changes to the design as it is improved.
- Presentations will be made to the class once every 2 weeks to share findings and discuss problems and possible solutions.

At the conclusion of the 9-weeks, each group will present their final design to the class. The class will then decide which is the most economical and efficient design, based on the evidence collected and presented.

Lesson E. Earth's Tilt and Rotation
(Adapted from a WestEd Alliance notebook entry)

Students document the location of their shadows and the sun in the morning. They then predict where it will be that afternoon and document this in their notebooks. Using a blow-up globe, flashlight, and small plastic army men (or any other small toy figurine), students explain what alignment of the Earth, sun and themselves would cause the shadow to be where it is that morning. They then predict where their shadow will be that afternoon and use the globe, figurine and flashlight to explain why.

They return that afternoon to their same location and standing position. They record the location and direction of their shadows and the sun and document how they are different from that morning.
In their notebook, they will compare their prediction of where they thought their shadow was to where it actually was. They will then use the globe, figurine and flashlight to explain what alignment of the sun and earth causes their shadow to change the way it did. Any modifications to their original explanation will need to be documented.

Continuing:
Repeat the activity of having students draw the location of their shadows different days throughout the school year (in September, December, February, and April.) This will then lead into an explanation of Earth's tilt.

Claims and Evidence HO9

Title:

What is the point of view of the author (thesis) or the purpose of this article?	
Claim 1	**Evidence**
Claim 2	**Evidence**
Claim 3	**Evidence**

SAMPLE PAGES FROM STUDENT NOTEBOOKS HO10

Some samples are photocopied directly from student notebooks and others have been typed with student responses *italicized*.

Prompts or directions are listed at the top of each page

Write the definition of each term from Section 2 of Chapter 8.

<u>Segregate</u>- Alleles go to different cells while eggs and sperms are formed

<u>Heterozygous</u>- organism that contains two separate alleles that have the same trait. (Aa)

<u>Dominant</u>- The toughest ~~leader~~ one of all (or more powerful than the rest).

<u>Phenotype</u>- an organism's ~~outside~~ overall appearance

<u>Gene</u>- order of DNA that determines a trait

<u>Genotype</u>- what an organism is made up of

<u>Allele</u>- ~~one~~ one of many types of a gene

<u>Homozygous</u>- organism with 2 of the same alleles for a certain trait (AA)

<u>Recessive</u>- Allele that is present, but unexpressed.

<u>Independent Assortment</u>- segregation of genes during the assortment of gametes.

<u>Wild Type</u>- Commonly expressed genes for a certain organism.

<u>Dihybrid Cross</u>- More than 1 trait being used (cross-mating) both heterozygous
Rr Bb x Rr Bb

<u>Monohybrid Cross</u>- 1 trait being used; heterozygous
Rr x Rr

<u>Parental generation</u>- original / biological parents

<u>F_1 generation</u>- first generation (result of parental generation)

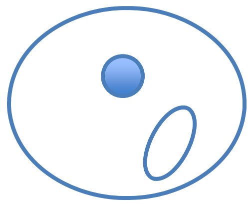
<u>Locus</u>- location of a gene on a chromosome

<u>Gamete</u>- cell that's part of sexual reproduction

Day 1: Monday, November 4, 2011

Focus Question: What is similar and different about plant and animal cells? Why are they similar, why are they different?

Prompt: Write and draw what you know about animal and plant cells.
Cells are small things. Plant and animal cells are different. Plant cells have chloroplasts. Plants make their food. Plants need sunlight and water. Plant cells are simpler.
I have blood cells.



Reading Notes

- *All living things are made out of one or more cells*
- *Cells carry out the function of life*
- *Cells have organelles*
- *Plant cells have cell walls and are rectangular*
- *Plant cells have chloroplasts to help make food*
- *Animal cells are different shapes.*
- *Animal cells don't have cell walls*
- *Both plant and animal cells have:*
  - *Plasma "cell" membrane*
  - *Nucleus*
  - *Mitochondria*
  - *Cytoplasm*

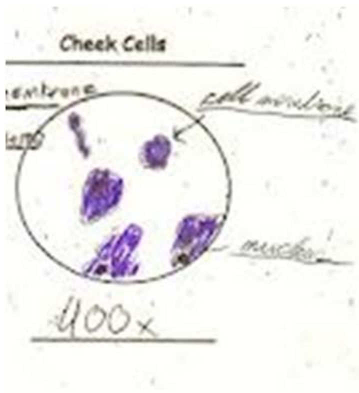
Prompt: Pick one note and write about why you think it is important.
Animal cells don't have cell walls. I'm not sure what a cell wall is. Why don't animals have them?

Compare with your neighbor and add one new idea
Cell walls enable plants to stand up. That must be why animal cells don't have them. I think animals have backbones.

Day 2: Tuesday, November 5, 2011

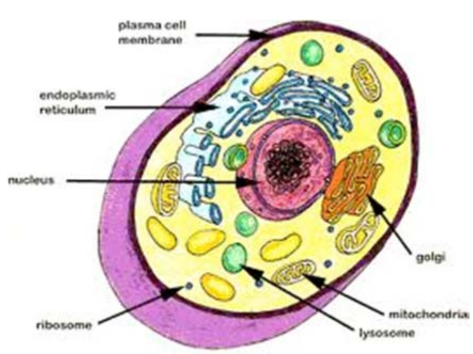
Prompt: observe a cheek cell and cell of a lily leaf under the microscope. Draw and label what you observe.

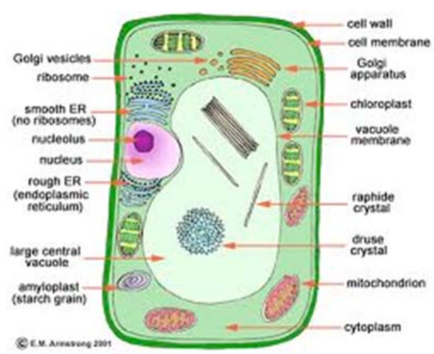
Microscope Drawings (400x)



Prompt: Use your drawings from the text to label the part of the cell.

Cell Drawings from page 73





My cells don't look like this. Are they supposed to be square? How come I can't see all the stuff in my drawigs?

Prompt: Compare and contrast your microscope drawing with the drawing in the text. What do you notice? Use notes from your reading to answer this question.

- *From my reading notes, the microscope lab and the drawings, I know that plants and animals are made out of cells. They both have organelles like: nucleus, mitochondria, cell membrane, vacuoles, cytoplasm. Only plant cells have chloroplasts and a cell wall. The plant cell is rectangular and the animal cell is round.*
- *In the microscope I could only see some of the organelles that are in the pictures. The diagram showed more.*

Prompt: What are you thinking about now?

- *I thought plants were simpler, but I don't think so anymore because of the drawing and looking at it through the microscope. I know that plants and animal cells have similar organelles and different organelles, but I don't know why.*
- *I wonder if all cells look like the ones we looked at?*

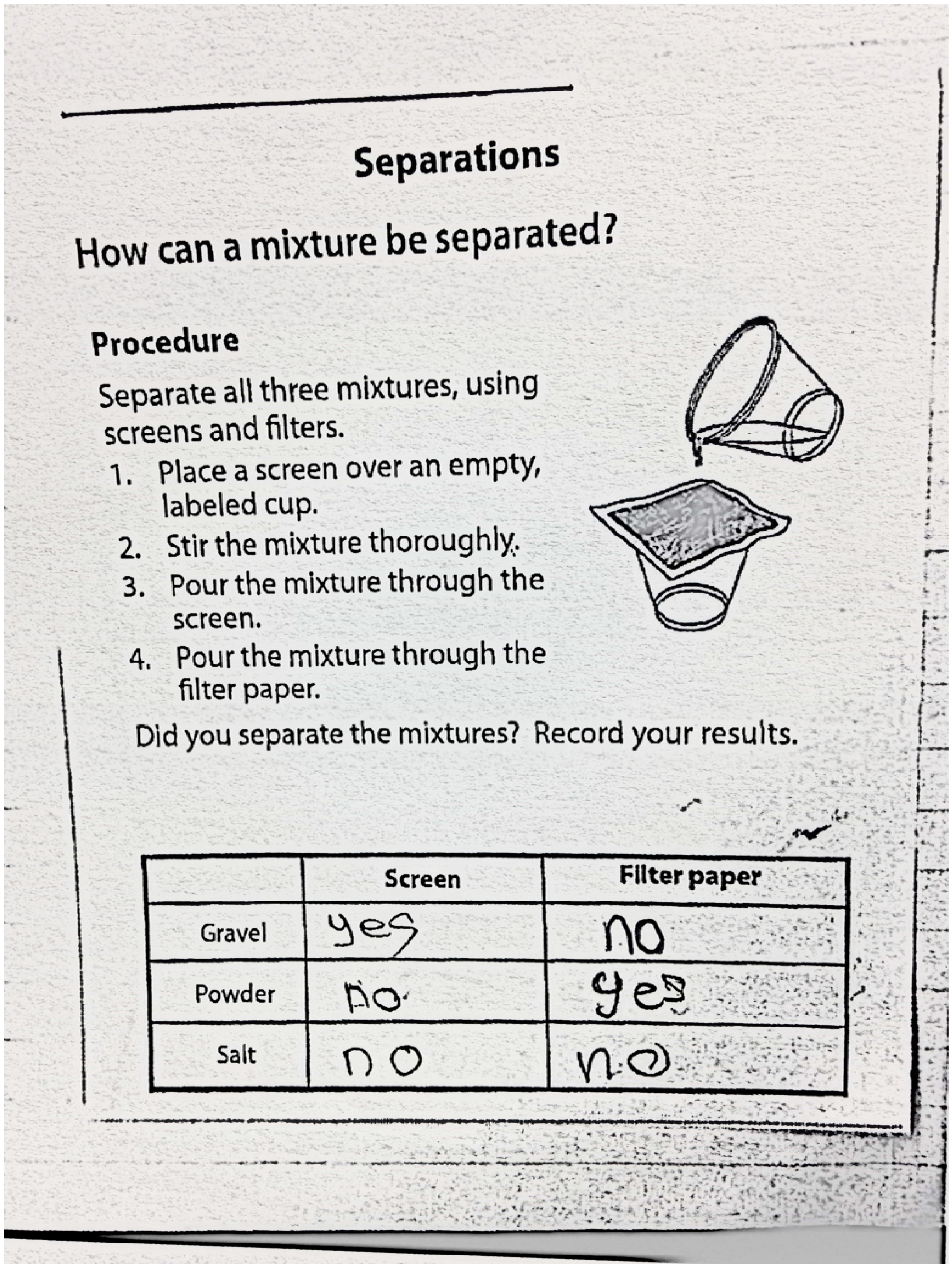
Prompt: Read over the list of elements and mark those that you are familiar with. Write a thing or place that you associate with each of them.

ELEMENTS CHECKLIST

- [ ] Actinium
- [x] Aluminum Foil
- [ ] Antimony
- [ ] Argon
- [ ] Arsenic
- [ ] Astatine
- [ ] Barium
- [ ] Beryllium
- [ ] Bismuth
- [ ] Boron
- [ ] Bromine
- [ ] Cadmium
- [x] Calcium dentist
- [x] Carbon School
- [ ] Cerium
- [ ] Cesium
- [x] Chlorine t.v.
- [ ] Chromium
- [ ] Cobalt
- [x] Copper vidio
- [ ] Dysprosium
- [ ] Erbium
- [ ] Europium
- [x] Fluorine dentist
- [ ] Francium
- [ ] Gadolinium
- [ ] Gallium
- [ ] Germanium
- [x] Gold My neckles
- [ ] Hafnium
- [x] Helium Dollartre
- [ ] Holmium
- [x] Hydrogen vidio
- [ ] Indium
- [ ] Iodine
- [ ] Iridium
- [x] Iron vidio
- [x] Krypton School
- [ ] Lanthanum
- [ ] Lead
- [ ] Lithium
- [ ] Lutetium
- [ ] Magnesium
- [ ] Manganese
- [x] Mercury temp
- [ ] Molybdenum
- [ ] Neodymium
- [x] Neon Sun
- [x] Nickel Coin
- [ ] Niobium
- [x] Nitrogen sciencetwe
- [ ] Osmium
- [x] Oxygen air
- [ ] Palladium
- [ ] Phosphorus
- [ ] Platinum
- [ ] Polonium
- [x] Potassium Banana
- [ ] Praseodymium
- [ ] Protactinium
- [ ] Radium
- [ ] Radon
- [ ] Rhenium
- [ ] Rhodium
- [ ] Rubidium
- [ ] Ruthenium
- [ ] Samarium
- [ ] Scandium
- [ ] Selenium
- [ ] Silicon
- [x] Silver ring
- [ ] Sodium
- [ ] Strontium
- [ ] Sulfur
- [ ] Tantalum
- [ ] Tellurium
- [ ] Terbium
- [ ] Thallium
- [ ] Thorium
- [ ] Thulium
- [ ] Tin
- [ ] Titanium
- [ ] Tungsten
- [ ] Uranium
- [ ] Vanadium
- [ ] Xenon
- [ ] Ytterbium
- [ ] Yttrium
- [x] Zinc t.v
- [ ] Zirconium

234

Read and follow the directions on the lab sheet.



Separations

How can a mixture be separated?

Procedure

Separate all three mixtures, using screens and filters.

1. Place a screen over an empty, labeled cup.
2. Stir the mixture thoroughly.
3. Pour the mixture through the screen.
4. Pour the mixture through the filter paper.

Did you separate the mixtures? Record your results.

	Screen	Filter paper
Gravel	yes	no
Powder	no	yes
Salt	no	no

Day 1: Monday, Dec. 19, 2011

Focus Question: How does the steepness of a ramp effect the speed of a marble rolling 1 meter (100cm)?

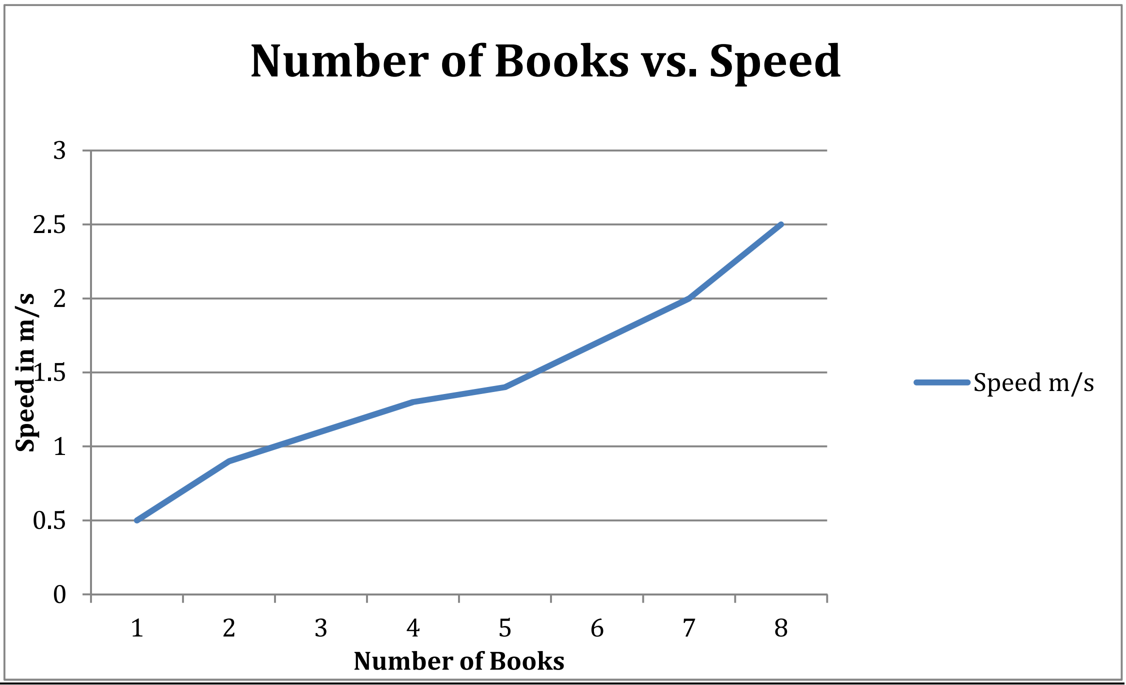
Prompt: Make a prediction and explain your thinking.
I think that the steepest ramp will cause the marble to roll the fastest because if it is really high, the marbles will speed up.

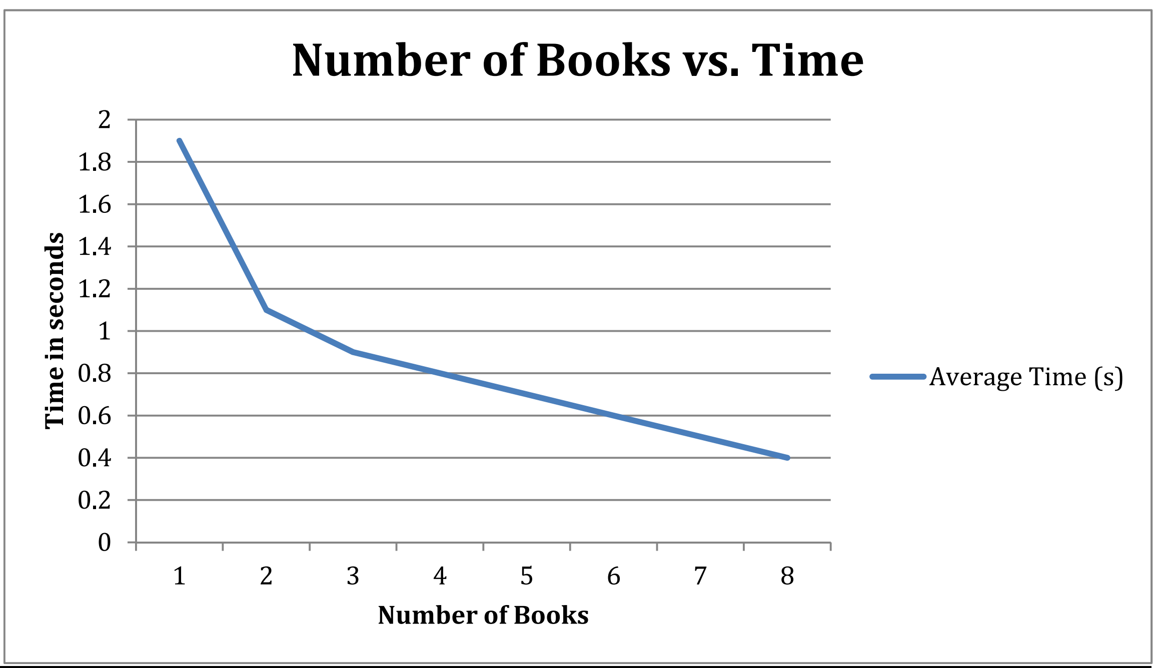
Prompt: Conduct the experiment and create a data table. Record your data in the table.

# of Books	***Trial 1 (s)***	***Trial 2 (s)***	***Trial 3 (s)***	***Average Time (s)***	***Speed m/s***
1	**2.1**	***1.7***	***1.8***	***1.9***	***0.5***
2	**1.1**	***1.2***	***1.1***	***1.1***	***0.9***
3	**1.0**	***0.9***	***0.8***	***0.9***	***1.1***
4	**0.8**	***0.9***	***0.9***	***0.8***	***1.3***
5	**0.7**	***0.6***	***0.7***	***0.7***	***1.4***
6	**0.6**	***0.6***	***0.5***	***0.6***	***1.7***
7	**0.5**	***0.5***	***0.4***	***0.5***	***2.0***
8	**0.5**	***0.4***	***0.4***	***0.4***	***2.5***

Prompt: What questions do you have about your chart.
My average time is going down and the speed is going up. I think that means its faster. I'm not sure why there seems to be a greater change in book 1 and 2 and the rest. Should that be the same?

Prompt: Graph your data





Prompt: What does your data indicate?

At a ramp height of 8 books, the speed was 2.5 m/s. At a ramp height of 1 book, the speed was 0.5 m/s. Therefore, the higher the slope the faster the speed of the object rolling 100cm.
At a ramp height of 8 books, the average time was 0.4 seconds. At a ramp height of one book, the average time was 1.9 seconds. Therefore, the higher the slope, the less average time for the marble to travel 100cm.

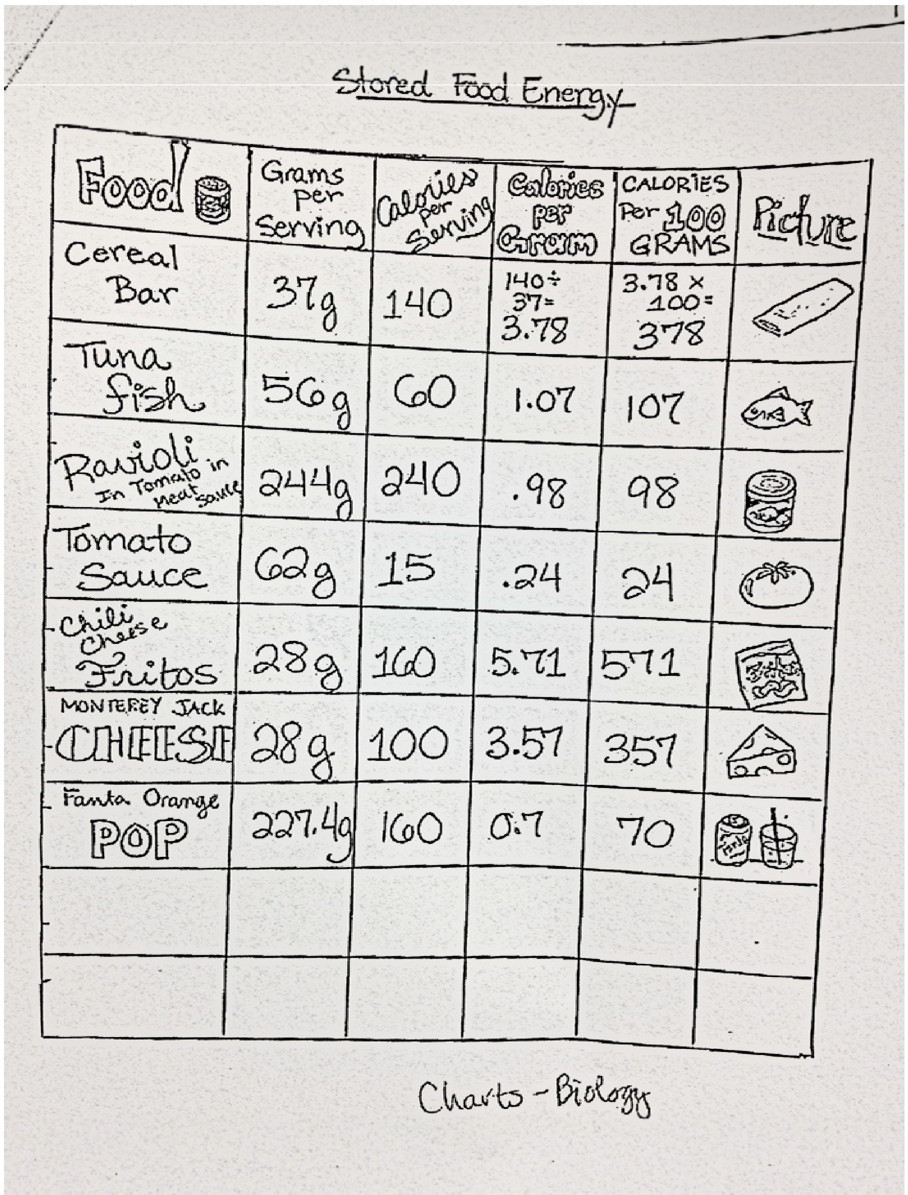
This is because it has a greater force at the bottom of the ramp causing the marble to move faster.

Prompt: What did you learn? What still confuses you?

My prediction is supported by my data. I know that the height gives more force to the marble, but I wonder if it would work on a different sized marble, or another kind of ball.

I am confused about speed and acceleration and how forces work on those.

Directions: Choose 9 foods from your house and record the following information about them in a table: grams/serving, calories/serving. Then determine and record the calories/gram and calories/100 grams. Include the label or a picture of each food.



Stored Food Energy

Food	Grams Per Serving	Calories Per Serving	Calories per Gram	CALORIES Per 100 GRAMS	Picture
Cereal Bar	37g	140	140÷37= 3.78	3.78 × 100= 378	
Tuna fish	56g	60	1.07	107	
Ravioli In Tomato in Meat Sauce	244g	240	.98	98	
Tomato Sauce	62g	15	.24	24	
Chili Cheese Fritos	28g	160	5.71	571	
MONTEREY JACK CHEESE	28g	100	3.57	357	
Fanta Orange POP	227.4g	160	0.7	70	

Charts - Biology