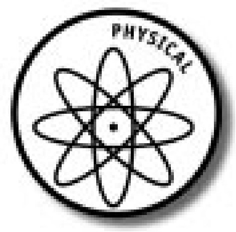
Translating Standards to Practice

A Teacher's Guide to Use and Assessment of the Alaska Science Standards



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Developed collaboratively by the Alaska State Department of Education & Early Development and the Alaska Rural Systemic Initiative with funding provided by the National Science Foundation.

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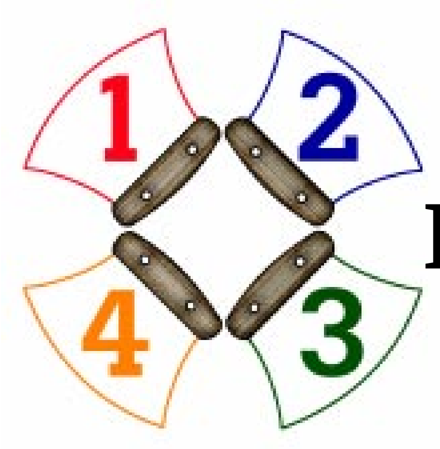

Introduction

Translating Standards to Practice: A Teacher's Guide to Assessment of the Alaska Science Standards were developed by Alaska educators and members of the business, native, and scientific communities to help promote scientific literacy and understanding for Alaska science students. As such, they were written to enhance, complement, and integrate the *Alaska Science Content Standards* and the *Alaska Standards for Culturally Responsive Schools* to further education in the sciences. These standards borrow heavily from the *National Science Education Standards* (NRC, 1995) as well as the *Benchmarks for Science Literacy* (AAAS, 1993) and are intended to help teachers provide students with an integrated and comprehensive understanding of science. Additionally, they were written to help enhance student understanding of Alaska culture, including the traditional and the scientific, and how they relate to one another. Teaching how the traditional and scientific relate to one another, through the use of *Translating Standards to Practice: A Teacher's Guide to Assessment of the Alaska Science Standards*, can provide an exciting and educational process that will invoke a sense of pride and self confidence in both students and teachers. The standards were developed collaboratively by the Alaska State Department of Education & Early Development and the Alaska Rural Systemic Initiative, with funding generously provided by the National Science Foundation.

Purpose

In 1994 the *Alaska Science Content Standards* were published with the goal of defining what students should know and be able to do in science by the time they complete their K–12 public education experience. These guidelines elaborate the expectations regarding student achievement and explain *how well* students should understand important scientific concepts and skills and how they relate to the environment around them. Corresponding assessments, supporting classroom ideas, and samples of student work were added to show how they might fit in a curriculum. These illustrate what *meeting the standard* may look like in the classroom. The sample assessments, which are in measurable terms, with a scoring guide, have been provided. The assessments can then be used to provide feedback to the students about how well they are meeting expectations. The assessments are also feedback to educators about how well their students are learning and how well they are meeting the *Alaska Science Content Standards*. It is important to note that these guidelines, assessments, and procedures were written illustratively—as ideas—not mandates. It should also be understood that this document is intended to help provide guidance to districts through the examples provided as they make choices regarding which standards to focus on at various benchmark age levels, as well as what *aspects* of the standards are focused on and when. The standards were written to reflect the diversity and richness of Alaska that makes teaching Alaskan students so exciting. Therefore, teachers may use them as guidelines for writing their own performance assessment activities or simply as examples to better understand particular aspects of the content standards at benchmark age levels. The standards were written to provide ideas relating to the wisdom of the cultural traditions of the Elders as well as the technological advances of the scientific community, bridging the gap between science and cultural practices to make learning more fun and appealing.

About This Document

This document presents an expanded view of the content standards for Alaska students. Performance standard statements have been written at each benchmark age level (5–7, 8–10, 11–14, 15–18). However, this document is really a "sampler" as examples of the expanded performance assessments, corresponding procedures, scoring guides, and in a very few cases, sample mini-units (elaborated classroom units), are provided for only a portion of the *Alaska Science Content Standards*—A, B, C, and D. The schematic shown below and "definitions" of the components of the document illustrate how the document is organized. The electronic version can be accessed via the Alaska Native Knowledge Network website at http://www.ankn.uaf.edu. Cross references to other pertinent Alaska standards, as well as to the National Research Council's *National Science Education Standards* and the American Association for the Advancement of Science's *Benchmarks for Science Literacy*, have been provided to show connections and further illuminate the intention of the *Alaska Science Content Standards*.

This document does **not** provide a list of mandated understandings and skills. The content standards provide a broad overview of essential learnings. The four domains described in the A, B, C, and D statements are elaborated by the key elements and describe what we agree are essential to the discipline and should be learned by all students in Alaska. The specific dimension of the content standards that should be taught and the performance to show mastery are the choice of the district, community, school, or classroom, not the document. This document is a guide for making the choice at the local level.

Definitions

Content Standard
What Alaskans want students to know and be able to do as a result of their public schooling.

Key Element
An important focus within a content standard.

Performance Standard
An example of how students at a specific age level demonstrate proficiency and understanding of a content standard focus (key element).

Sample Assessment Idea
A potential task designed to assess a student's proficiency and understanding of a performance standard.

Expanded Assessment Idea
A sample assessment idea elaborated to include procedure, reflection and revision, and level of performance.

Procedure
Step-by-step instructions to guide the implementation of an expanded assessment idea.

Reflection and Revision
A final step of procedure, which represents a collection of brief ideas or methods, intended to strengthen, clarify, and improve student understanding and proficiency.

Level of performance
A task-specific scoring guide used to assess how well students meet the performance standard.

Frequently Asked Questions

Why was *Translating Standards to Practice: A Teacher's Guide to Assessment of the Alaska Science Standards* document written?

It was prepared to:

- elaborate the Alaska Science Content Standards to more fully explain what students need to know and are able to do;
- help guide curriculum development in schools and districts;
- provide sample developmentally appropriate activities for each standard;
- provide educators with innovative performance assessment activities.

What are Performance Standards?

Performance standards define the nature of the evidence and quality to which a student understands the content standards.

What makes performance standards different from content standards?

The content standards are designed to broadly define what scientific concepts, skills, and applications are to be taught in Alaska's schools, whereas these guidelines are more detailed definitions of how well students need to know the science and what they ought to be able to do with that knowledge.

What are performance assessments?

Performance assessments help define how well students:

- understand science;
- show what they can do;
- relate science to society;
- communicate knowledge

by providing performance opportunities for students to demonstrate their understanding.

Why should I use performance activities with my students?

- To document student progress in meeting the Alaska Science Content Standards.
- To help students become accountable for their learning.
- To provide opportunities for students to learn by "doing."
- To give students a variety of opportunities to show that they can "meet" the content standards.

What if I can't use a particular performance assessment in my classroom?

The performance assessments were written as sample suggestions. You may use them as models for writing your own performance assessment activities.

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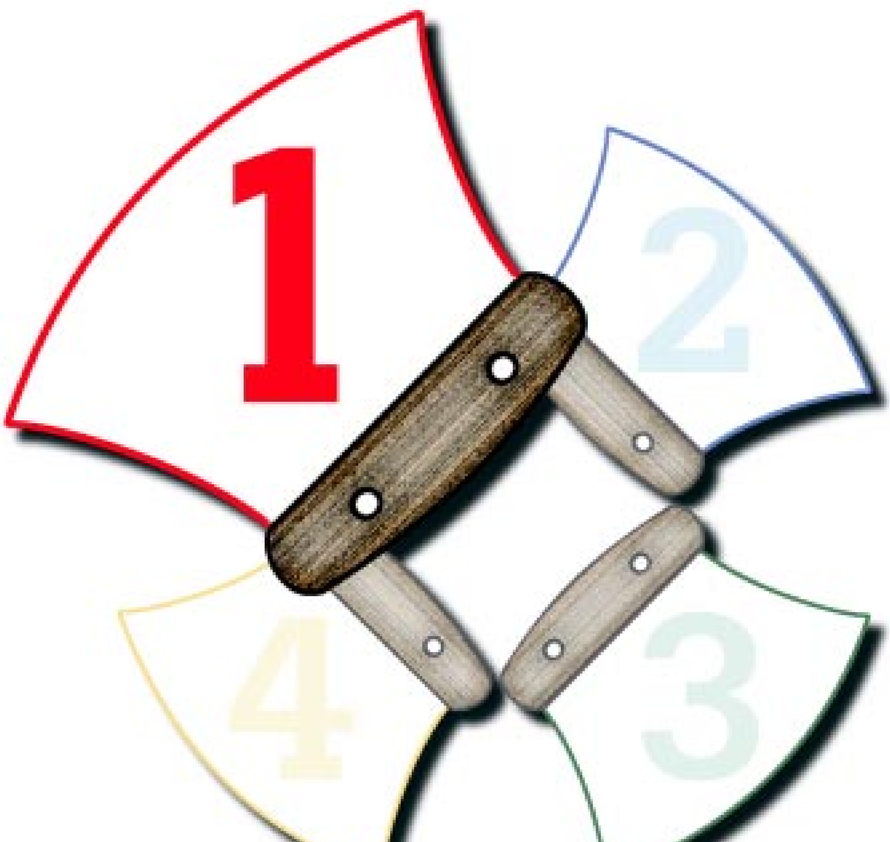
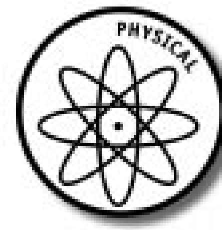
LEVEL 1, Ages 5–7





Alaska Science Content Standard A

Level 1, Ages 5–7

A student should understand scientific facts, concepts, principles, and theories.

Alaska Science Key Element A1

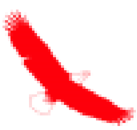
A student who meets the content standard should understand models describing the nature of molecules, atoms, and sub-atomic particles and the relation of the models to the structure and behavior of matter (Structure of Matter).

Performance Standard Level 1, Ages 5–7

Students use models to represent structures and identify different scale relationships.

Sample Assessment Ideas

- Students use blocks to build models of fruits, vegetables, animals, and so on, to illustrate that objects may be made of small parts that do not resemble the final object.
- Students examine feathers, fur, and fish scales by eye, with a magnifying glass, and with a microscope; report observations in terms of similarities and differences; report how these things may be useful to the animal.



Expanded Sample Assessment Idea

- Students observe various kinds of fabric with a hand lens; describe what they have seen to an adult; create a model that shows their observations of the structure of the fabric.

Procedure

Students will:

1. Select a fabric (cotton, linen, wool, nylon mesh, burlap, etc.); observe the fabric with the naked eye; draw a picture of the fabric; describe the fabric to an adult.
2. Observe the fabric with a hand lens; draw a picture of the fabric; describe the fabric to an adult.
3. Observe the fabric with a microscope; draw a picture of the fabric; describe the fabric to an adult.
4. Design and build a model that represents the fabric observations. (Useful craft materials might include paper, additional fabric samples, styrofoam, weaving materials, pipe cleaners, yarns, threads, ropes or strings of various diameter.)

Reflection and Revision

Describe how the model represents the observations. Describe similarities and differences in the various fabrics observed by classmates. What fabric would be good for soaking up water? For making a piece of fancy clothing? For carrying fish back to your house? What did you see in the magnified fabric that helped you decide?

Levels of Performance

Stage 4

Student work is complete, correct, and shows evidence of logical reasoning. The completed model is detailed and accurately represents several observations of the magnified fabric sample. Student explanations of the model and how the fabric can be used show multiple examples of transfer and extension of knowledge. They include several examples of similarities and differences in the fabrics examined by the class as well as detailed descriptions that relate the magnified view of fabric to its possible uses.

Stage 3

Student work shows evidence of logical reasoning but may contain minor errors or omissions. The completed model is detailed and represents observations of the magnified fabric sample. Student explanations of the model and how the fabric can be used show examples of transfer and extension of knowledge. They include at least one similarity and one difference in the fabrics examined by the class as well as a description of how the structure of a fabric relates to how it might be used.

Stage 2 Student work shows limited evidence of knowledge transfer or extension and may contain errors of science fact and reasoning. The completed model may contain evidence of skilled craftsmanship but may be incomplete, incorrect or lack detail.

Stage 1 The completed models and explanation are largely incomplete or incorrect and show little or no evidence of knowledge relating models and scaled structures to objects and their uses

Standards Cross-References

National Science Education Standards

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools such as rulers, balances, and thermometers. (Page 127)

Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials. (Page 127)

Benchmarks

Objects can be described in terms of the materials they are made of (clay, cloth, paper, etc.) and their physical properties (color, size, shape, weight, texture, flexibility, etc.) (Page 76)

Some kinds of materials are better than others for making any particular thing. Materials that are better in some ways (such as stronger or cheaper) may be worse in other ways (heavier or harder to cut). (Page 188)

Many of the toys children play with are like real things only in some ways. They are not the same size, are missing many details, or are not able to do all of the same things. (Page 268)

A model of something is different from the real thing but can be used to learn something about the real thing. (Page 268)

Alaska Science Key Element A2

A student who meets the content standard should understand the physical, chemical, and nuclear changes and interactions that result in observable changes in the properties of matter (Changes and Interactions of Matter).

Performance Standard Level 1, Ages 5–7

Students observe physical properties of substances and observe that a substance maintains many of the same properties whether it is big or small.

Sample Assessment Ideas

- Students use a magnifying glass to observe an object (piece of paper, wood); cut the object into smaller pieces; observe the smaller pieces under a magnifying glass; recognize and describe similarities.
- Students observe and recognize the similarities in iron as it exists in different places, (e.g. a nail, a guardrail, a hammer head); using hardness, reaction to a magnet, rusting over time or density tests.

Expanded Sample Assessment Idea

- Students observe different shapes and sizes of candle wax; determine properties of candle wax.

Procedure

Students will:

1. Observe a variety of properties of the unlit candle eg. color, feel (hardness), does it float or sink in water? (density); describe and draw observations in journal.
2. Observe an adult light the candle; drip the wax into different shape molds (these can be made earlier as an art activity); remove wax from molds when wax cools and hardens.
3. Observe the new wax pieces using the same tests as above; record observation in journal.

Reflection and Revision

Think, discuss and report—what changes did the candle go through? Were the properties of the new small wax molds different from each other or from the original candle? What does this tell about the liquid and solid wax?

Levels of Performance

Stage 4 — Student work is complete, correct, and shows detailed evidence of knowledge related to physical properties of common substances. Multiple journal entries accurately record all before and after melting observations of the candle wax (color, hardness, and density). Explanations of physical changes and physical properties are correct and show no evidence of misconceptions.

Stage 3 — Student work shows evidence of knowledge related to physical properties of common substances. Multiple journal entries record most before and after melting observations of the candle wax (color, hardness, and density). Explanations of physical changes and physical properties may contain minor errors or omissions but show no evidence of misconceptions.

Stage 2 — Student work is incomplete and shows limited evidence of knowledge related to physical properties of common substances. Journal entries may be limited in number or show evidence of misconceptions related to the changes in the properties of candle wax after melting.

Stage 1 — Student work is mostly incomplete, or shows evidence of multiple misconceptions related to the physical properties, and physical changes of common substances.

Standards Cross-References

National Science Education

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. (Page 127)

Benchmarks

Things can be done to materials to change some of their properties, but not all materials respond the same way to what is done to them. (Page 76)

Alaska Science Key Element A3

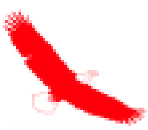
A student who meets the content standard should understand models describing the composition, age, and size of our universe, galaxy, and solar system and understand that the universe is constantly moving and changing (Universe).

Performance Standard Level 1, Ages 5–7

Students make observations of the daytime and nighttime sky over a period of time and chart the movement of objects.

Sample Assessment Ideas

- Students draw a picture that compares day and night positions of the sun and moon from a window in their homes.



Expanded Sample Assessment Ideas

- Students chart movements of the sun and the moon from the classroom.

Procedure

Students will:

1. Select a window in their classroom or school where they can identify the position of the sun and the moon.
2. Draw and label at least six pictures of the window with the changing position of the sun and the moon between the hours of 9 a.m. and 4 p.m.
3. Share pictures in class; discuss patterns and changes observed; identify east and west on the picture.
4. Consolidate the student work to create a sun and moon location chart for that day.

Reflection and Revision

What could you do to make your drawings a more exact picture of the location of the sun and the moon? Draw a picture that predicts where the sun and the moon will be at 5 p.m.

Level of Performance

Stage 4 — Student work is detailed and correctly labeled. Student work shows detailed evidence of extension of knowledge by correctly predicting location of the sun and the moon later in the day.

Stage 3 — Student work is detailed or correctly labeled. Student work shows some evidence of extension of knowledge by predicting location of the sun or moon later in the day.

Stage 2 — Student work is incomplete, incorrect or lacks detail. Student work shows limited evidence of extension of knowledge to a new situation. Student work contains inaccuracies or misconceptions about the movement of the sun and moon in the sky.

Stage 1 — Student work shows little or no evidence of understanding how the sun and moon move in the sky. Pictures may show craftsmanship but the work is mostly incomplete, incorrect, and contains misconceptions

Standards Cross-References

National Science Education Standards

An object's motion can be described by tracing and measuring its position over time. (Page 127)

Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle that lasts about a month. (Page 134)

The sun, moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described. (Page 134)

Benchmarks

There are more stars in the sky than anyone can easily count, but they are not scattered evenly, and they are not all the same in brightness or color. (Page 62)

The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky. (Page 62)

The moon looks a little different every day, but looks the same again about every four weeks. (Page 62)

Alaska Science
Key Element A4

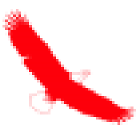
A student who meets the content standard should understand observable natural events such as tides, weather, seasons, and moon phases in terms of the structure and motion of the Earth (Earth).

Performance Standard Level 1, Ages 5–7

Students observe natural events and identify patterns in the weather and the seasons.

Sample Assessment Ideas

- Students work with their classmates to chart the weather on a daily calendar.
- Students identify the difference between day and night, summer and winter in their community.



Expanded Sample Assessment Idea

- Students keep a daily journal identifying weather patterns across seasons.

Procedure

Students will:

1. Learn weather-related words and phrases in English and Native languages, including terms to describe the weather (wind direction, wind speed, cloud type, cloud cover, temperature, seasons and so on).
2. Discuss the weather with Elders, including indigenous sayings related to the weather.
3. Take turns identifying weather conditions.
4. Draw or write observations on the classroom chart.
5. Continue to chart the weather with the class for several months.

Reflection and Revision

Use the weather chart to make a graph of the number of inside recess and outside recess days. What information from the weather chart did you use to help you decide if it was an inside recess day or an outside recess day? Draw a picture that predicts the weather for the following week. Explain how you used information in the weather chart to make your prediction.

Level of Performance

Stage 4 — Student work is complete and correct. Student uses appropriate terms in more than one language to describe the weather in detail. Student drawing, graph, and explanation are accurate and each shows evidence of higher-level thinking. Student explanation shows evidence of extension of knowledge through detailed predictions.

Stage 3 — Student work is generally correct, but may contain minor errors or omissions. Student uses appropriate terms in more than one language to describe the weather. Student drawing, graph, and explanation are accurate. Student's prediction is correct, but may lack detail.

Stage 2 — Student attempts to use more than one language to describe the weather, although several of the terms may be incorrect or inappropriate. Student drawing, graph, or explanation may be incomplete, incorrect, or lack detail. Student work may contain misconceptions and errors of science fact and reasoning.

Stage 1 — Although the work may be on topic, the student uses incorrect terms in one or both languages to describe the weather. Student drawing, graph, and explanation are largely incomplete, incorrect, and show little or no evidence of understanding weather and weather patterns.

Standards Cross-References

National Science Education Standards

Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation. (Page 134)

Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle that lasts about a month. (Page 134)

Benchmarks

The moon looks a little different every day, but looks the same again about every four weeks. (Page 62)

Some events in nature have a repeating pattern. The weather changes from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year. (Page 67)

Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing. (Page 67)

Water left in an open container disappears, but water in a closed container does not disappear. (Page 67)

Alaska Science Key Element A5

A student who meets the content standard should understand the strength and effects of forces of nature, including gravity and electromagnetic radiation (Forces of Nature).

Performance Standard Level 1, Ages 5–7

Students show how objects can be moved without being touched, and how shadows are formed by light.

Sample Assessment Ideas

- Students demonstrate that they understand that objects fall to the ground if support is withdrawn.
- Students describe the pushing and pulling forces of magnets on one another and on different objects
- Students predict the direction and shape of a shadow of an object illuminated from one side by a lamp or by the sun.

Standards Cross-References

National Science Education Standards

Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object. (Page 127)

Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. (Page 127)

Magnets attract and repel each other and certain kinds of other materials. (Page 127)

Benchmarks

The sun warms the land, air and water. (Page 83)

Things near the Earth fall to the ground unless something holds them up. (Page 94)

Magnets can be used to make some things move without being touched. (Page 94)

Alaska Science Key Element A6

A student who meets the content standard should understand that forces of nature cause different types of motion, and describe the relationship between these forces and motion (Motion).

Performance Standard Level 1, Ages 5–7

Students observe and record changes in an object's position and motion when applying a push or pull.

Sample Assessment Ideas

- Students describe or demonstrate the pushes or pulls that can be used to move an object through a simple maze.
- Students explain the motions of a balance or teeter-totter in terms of the "weight" of objects placed on it.

Expanded Sample Assessment Idea

- Students build a game where marbles collide; measure the distance and direction (angle) of marbles that have collided.

Materials

Graph paper, tray with flat bottom, large sheets of paper, 12-inch diameter paper circles, marbles, ruler, marking pens

Procedure

Students will:

1. Cut a piece of paper large enough to fit snugly, yet lie flat, in the bottom of the tray. Remove the paper from the tray.
2. Fold a 12-inch diameter circle in half and firmly press the edge of the fold; fold in quarters, eighths and sixteenths; open the circle; refold along the same lines but in the opposite direction to help flatten the folds so they do not curl the edge of the circle.
3. Put the circle in the middle of the tray paper; hold the circle flat with one hand and mark a dot on the tray paper each place a fold touches the tray paper; connect the opposite dots to create a design similar to this: * (Each student should prepare one of these forms but can use teacher prepared tray papers for their additional trials.)
4. Put the tray paper back in the tray.
5. Place one marble in the tray at the center crossing point; place a second marble at the edge of the tray along another of the lines.
6. Mark the starting position of the second marble.
7. Carefully roll the second marble so that it collides with the first marble.
8. Mark the position of both marbles when they stop; remove the marbles from the tray.
9. Use a marking pen to draw and label the path of each marble.
10. Measure how far each marble went.
11. Repeat steps 4–10 using a new tray paper but keep the same position for the second marble.
12. Repeat steps 4–11 using a new starting position for the second marble.
13. Repeat steps 4–11 using a variety of marbles (2 large, 1 large and 1 small, marbles made of different materials, and so on).
14. Compare the results with others in class.

Reflection and Revision

What caused the first marble to move after the collision? Did the repeat marble collision always get the same results as the first collision? What would happen if the two marbles were not the same size? If the marbles were not made of the same material? How can you tell how much push you gave to the second marble to start it moving? How could you change the game so that every marble got the same amount of push to start it moving? When you examine the class results, is there a pattern to the motion for different marbles?

Levels of Performance

Stage 4 — Student work is complete and shows detailed evidence of the transfer and extension of knowledge related to how a push or pull changes the position or motion of an object. The student creates at least four complete sets of marble path diagrams that are clearly labeled, tests several marble variations (size, material, starting position), and always includes the repeat experiment. The student examines class data, identifies and explains patterns of motion for different marbles, and designs a method to deliver a uniform push for each marble roll.

Stage 3 — Student work is complete and shows some evidence of the transfer or extension of knowledge related to how a push or pull changes the position or motion of an object. The student creates at least two sets of marble path diagrams that are labeled, tests several marble variations (size, material, starting position), and includes the repeat experiment although aspects of the diagrams may be unclear. The student examines class data, identifies patterns of motion for different marbles, and designs a method to deliver a similar push for each marble roll.

Stage 2 — Student work may be incomplete and show little evidence of knowledge related to changes in the position or motion of an object. The student creates marble path diagrams that are incomplete or lack labels The student may attempt to design a method to deliver a similar push for each marble roll.

Stage 1 — Student work is mostly incomplete and contains misconceptions related to the position or motion of an object. Marble path diagrams, if included, are incorrect or not labeled. Attempts to design a method to deliver a push for each marble roll may be inappropriate to the game or not work.

Standards Cross-References

National Science Education Standards

The position of an object can be described by locating it relative to another object or the background. (Page 127)

An object's motion can be described by tracing and measuring its position over time. (Page 127)

The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull. (Page 127)

Benchmarks

Things move in many different ways, such as straight, zigzag, round and round, back and forth, and fast and slow. (Page 89)

The way to change how something is moving is to give it a push or a pull. (Page 89)

Level 1

Alaska Science Key Element A7

A student who meets the content standard should understand how the Earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things (Processes that Shape the Earth).

Performance Standard Level 1, Ages 5–7

Students observe and describe earth materials such as clay, silt, sand, rocks, and pebbles that exist in a variety of sizes, shapes, colors, and hardness.

Sample Assessment Ideas

- Students dig a hole; observe and describe the different earth materials they discover
- Students test soft and hard materials by hitting them against each other (Proper SAFETY precautions should be used.)

Expanded Sample Assessment Idea

- Students classify a collection of rocks based on a variety of criteria.

Procedure

Students will:

1. Each collect at least five different local rocks and bring their collection to class
2. Make a list of characteristics most commonly used to describe the rocks.
3. Sort the five rocks in their collections according to one characteristic (for example, color, size, shape, hardness, or other student-selected category); describe the groups formed by this sort, record results in journal.
4. Sort the five rocks in their collections according to a new characteristic; describe the groups formed by this sort; record results in their journals.
5. In groups of three, sort and describe the combined rock collection in at least three different ways; describe the groups of rocks they made each time they used a new characteristic to sort them; record results in journal.

Reflection and Revision

What characteristic was easiest to use to categorize the rocks? Why?

Level of Performance

Stage 4

Student work is complete, and shows evidence of logical reasoning. Student work shows detailed evidence of ability to sort and describe earth materials using multiple characteristics. The student sorts and describes rocks using three different characteristics. Each sort cycle includes a description of the rock groupings made using that particular characteristic. Student work describes in detail the sorting and information analysis processes used to sort and group earth materials.

Stage 3

Student work, while generally correct, may contain minor errors and omissions. Student work shows evidence of ability to sort and describe earth materials using several characteristics. The student sorts and describes rocks using at least two different characteristics. Most sort cycles include a description of the rock groupings made using that particular characteristic. Student work describes the sorting process and analyzes the information collected during the sorting process.

Stage 2 — Student work contains errors and omissions. Student work shows limited evidence of ability to sort and describe Earth materials. Student may not describe the sorting process or analyze information about the rocks.

Stage 1 — Student work is largely incomplete or incorrect and shows little or no evidence of ability to sort or describe earth materials.

Standards Cross-References

National Science Education Standards

Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide all of the resources that humans use. (Page 134)

Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply. (Page 134)

The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. (Page 134)

Benchmarks

Chunks of rocks come in many sizes and shapes, from boulders to grains of sand and even smaller. (Page 72)

Change is something that happens to many things. (Page 72)

Animals and plants sometimes cause changes in their surroundings. (Page 72)

Level 1

Alaska Science Key Element A8a

A student who meets the content standard should understand the scientific principles and models that describe the nature of physical, chemical, and nuclear reactions (Energy Transformations).

Performance Standard Level 1, Ages 5–7

Students observe and describe changes in matter and identify some changes that are easily reversible and some that are not.

Sample Assessment Ideas

- Students describe how salt changes when they dissolve some in water then grow crystals back from solution.
- Students fold paper, cut holes in paper, and burn paper (Proper SAFETY precautions should be used); describe each change as reversible or non-reversible.

Expanded Sample Assessment Idea

- Students melt ice cubes into water; freeze the water and re-melt the ice; boil the water and make condensate.

Procedure

Students will:

1. Observe and describe ice cubes in a journal or during an oral discussion.
2. Melt ice cubes; observe and describe the resulting water in a journal.
3. Freeze the water; observe and describe the "new" ice cubes with a partner.
4. (Teacher does this) Boil the water; observe the steam and discuss it with the class. Is steam the same as fog or clouds? (NOTE: Yes, steam is seen when water vapor cools and condenses into tiny droplets.)

Reflection and Revision

Draw a picture of how the water changed. Draw a picture that shows some other ways to change the form of the water. Draw a picture that shows how we could get the steam to return water to the beaker. Is the substance always water, even when it is solid ice or solid snow or water in a glass or water in a stream or water in a cloud or rain? Draw a picture that shows how water changes in the water cycle.

Levels of Performance

Stage 4 — Student drawings show detailed evidence of knowledge about reversible changes that happen to water. Drawing #1 of the demonstration shows what happened during each step of the ice to water demonstration. Drawing #2 shows another way to change the form of water other than the process used in the classroom demonstration. Drawing #3 shows the three steps in the water cycle. Student explanation is correct, complete and shows evidence of logical reasoning.

Stage 3 — Student drawings show evidence of knowledge about reversible changes that happen to water. Drawing #1 of the demonstration shows what happened during the steps of the ice to water demonstration. Drawing #2 may show another way to change the form of water other than the process used in the classroom demonstration. Drawing #3 shows two steps in the water cycle. Student explanation shows evidence of logical reasoning but may contain minor errors or omissions.

Stage 2 — Student drawings show limited evidence of knowledge about changes that happen to water. Drawings may contain evidence of skilled artwork but may be incomplete, incorrect or lack detail.

Stage 1 — Student drawings show little or evidence of knowledge about changes that happen to water. Drawings may be largely incomplete or incorrect and show little evidence of understanding.

Standards Cross-References

National Science Education Standards

Materials can exist in different states—solid, liquid, and gas. Some common materials such as water can be changed from one state to another by heating or cooling. (Page 127)

Benchmarks

Things can be done to materials to change some of their properties, but not all materials respond the same way to what is done to them. (Page 76)

Alaska Science Key Element A8b

A student who meets the content standard should understand the scientific principles and models that state whenever energy is reduced in one place, it is increased somewhere else by the same amount (Energy Transformations).

Performance Standard Level 1, Ages 5–7

Students observe that the sun warms the land, air and water.

Sample Assessment Ideas

- Students examine and describe the effects of direct sunlight—measure the temperatures of water in sun and shade; exercise in the sun and in the shade; place white and dark colored objects in a sunny spot and feel the difference in temperature; compare the results when you repeat during another season.
- Students stand close to a hot stove or near a fire and describe what it feels like on the front and back of the body. Students then slowly rotate and describe how this experience is similar to objects warming in the sunshine and to the Earth as a whole.

Expanded Sample Assessment Idea

- Students compile and report on temperatures near water and on land over the year.

Procedure

Students will:

1. Discuss how best to get comparable information (same altitude, same time of day, and so on) to track weather patterns through the year.
2. Identify the information to be collected, such as cloudiness, temperature, wind direction, chill factor, and so on.
3. Identify another classroom group (this might be an e-mail classroom elsewhere in Alaska) who will share and compare information for this activity.
4. Collect, compile and chart temperature reports at locations near water (lakes or ocean) and at distances further from the water.

Reflection and Revision

Review information; look for patterns; discuss the patterns in terms of why the sun is heating the Earth differently at different locations and during different seasons.

Levels of Performance

Stage 4 Student work is complete, correct and shows detailed evidence of the transfer and extension of knowledge relating to factors that influence the sun's heating of the Earth. Student collects data reliably, clearly organizes the data, and logically interprets the data to identify several weather patterns.

Stage 3 Student work is mostly complete and shows evidence of the transfer or extension of knowledge relating to factors that influence the sun's heating of the Earth. Student collects and organizes data, and identifies patterns, though the work may contain minor errors, inconsistencies or omissions.

Stage 2 Student work may be incomplete and shows limited evidence of knowledge relating to weather patterns and the factors that influence the sun's heating of the Earth. Student collects and organizes weather-related data but may be unable to identify any weather patterns.

Stage 1 — Student work is mostly incomplete and shows misconceptions relating to the weather. Student may collect limited amount of data but does not organize or interpret it in a meaningful manner.

Standards Cross-References

National Science Education Standards

The sun provides the light and heat necessary to maintain the temperature of the Earth. (Page 134)

Benchmarks

The sun warms the land, air, and water. (Page 83)

Alaska Science Key Element A8c

A student who meets the content standard should understand the scientific principles and models that state that whenever there is a transformation of energy, some energy is spent in ways that make it unavailable for use (Energy Transformations).

Performance Standard Level 1, Ages 5–7

Students observe that there are many ways to produce heat and other forms of energy.

Sample Assessment Ideas

- Students demonstrate and/or explain three ways to warm hands on a cold day.
- Students list several different forms of energy and identify a source for each in their home or community.

Standards Cross-References

National Science Education Standards

Heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another. Heat can move from one object to another by conduction. (Page 127)

Electricity in circuits can produce light, heat, sound and magnetic effects. Electric circuits require a complete loop through which an electric current can pass. (Page 127)

Sound is produced by vibrating objects. The pitch of sound can be varied by changing the rate of vibrations. (Page 127)

The sun provides the light and heat necessary to maintain the temperature of the Earth. (Page 134)

Benchmarks

The sun warms the land, air, and water. (Page 83)

Alaska Science Key Element A9

A student who meets the content standard should understand the transfers and transformations of matter and energy that link living things and their physical environment from molecules to ecosystems (Flow of Matter and Energy).

Performance Standard Level 1, Ages 5–7

Students identify examples of living and non-living things in their environment and demonstrate understanding that things change over time

Sample Assessment Ideas

- Students grow a plant from a bulb (such as amaryllis, tulip, or iris); observe, measure, and draw accurate pictures to record the growth changes
- Students classify a variety of objects (or pictures) as living or non-living, as matter or energy.

Expanded Sample Assessment Idea

- Students care for a mealworm.

Procedure

Students will:

1. Provide food and water for their groups' mealworm.
2. Measure length and observe appearance of the mealworm at least twice a week.
3. Record measurements in science journal
4. Graph length change vs time.
5. Share results with rest of class; compare growth with the various mealworms

Reflection and Revision

Did all the mealworms grow the same amount?

Level of Performance

Stage 4 — Student journal contains multiple, detailed entries related to animal changes Data is organized in a simple data table Length of animal is graphed using a simple bar graph to show changes over time Comparison of mealworms is extensive and accurate

Stage 3 — Student journal contains multiple entries related to animal changes Data is grouped in a table Length of animal is graphed using a simple bar graph to show changes over time Descriptions and comparisons of mealworms may lack detail.

Stage 2 — Student journal contains limited entries related to animal changes Data is incomplete, or is not or organized. Graphs, if present are incomplete Descriptions of mealworms lack detail and do not include comparisons

Stage 1 — Student journal entries are largely incomplete

Standards Cross-References

National Science Education Standards

Organisms have basic needs. For example, animals need air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms. (Page 129)

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat plants. (Page 129)

Benchmarks

Plants and animals both need to take in water, and animals need to take in food. In addition, plants need light. (Page 119)

Many materials can be recycled and used again, sometimes in different forms. (Page 119)

Alaska Science
Key Element A10

A student who meets the content standard should understand that living things are made up mostly of cells and that all life processes occur in cells (Cells).

Performance Standard Level 1, Ages 5–7

Students use a hand lens to observe minute details of living things.

Sample Assessment Ideas

- Students observe different parts of plants (leaves, flowers, roots) with a hand lens; make detailed descriptions of the appearance such as size and texture; draw magnified and unmagnified views of the object.
- Students observe different parts of animals (insect wings, mouthparts, legs, antennae), mammals (hair, toenails, fingernails), fish (scales, gills), or birds (feathers, beaks, claws); make detailed descriptions of the appearance; draw magnified and unmagnified views of the object.

Standards Cross-References

National Science Education Standards

Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking. (Page 129)

Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and do things that they could not otherwise see, measure, and do. (Page 138)

Benchmarks

Magnifiers help people see things they could not see without them. (Page 111)

Most living things need water, food, and air. (Page 111)

Level 1

Alaska Science Key Element A11

A student who meets the content standard should understand that similar features are passed on by genes through reproduction (Heredity).

Performance Standard Level 1, Ages 5–7

Students identify similarities and differences between offspring and their parents.

Sample Assessment Idea

- Students observe a litter of puppies; compare the young animals to each other and to their parents.
- Students examine a portrait of a large family (or multigenerational family); list the features each child has in common with each parent. (NOTE: Use of a non-personal family portrait may reduce emotional turmoil in the classroom.)

Standards Cross-References

National Science Education Standards

Plants and animals closely resemble their parents. (Page 129)

Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation. (Page 129)

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment. (Page 157)

Benchmarks

There is variation among individuals of one kind or within a population. (Page 107)

Offspring are very much, but not exactly, like their parents and like one another. (Page 107)

Alaska Science
Key Element A12

A student who meets the content standard should distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life and understand the theories that describe the importance of diversity for species and ecosystems (Diversity).

Performance Standard Level 1, Ages 5–7

Students sort plants and animals into groups using consistent criteria, and describe how some characteristics are for the survival of the plant or animal.

Sample Assessment Ideas

- Students sort 5-bean soup mix using their own criteria; draw and label how the beans were sorted; discuss how different students use different criteria.
- Student groups collect and sort fifteen animal pictures based upon similarities or differences; create a group poster to explain how the animals were sorted; discuss how different animals have different characteristics; discuss how the characteristics of an animal help it to survive in its environment.

Expanded Sample Assessment Idea

- Students will take a nature walk; observe plant and animal life; collect samples of local plants.

Procedure

Students will:

1. Discuss acceptable ways to collect plants before walk.
2. Form pairs.
3. Go on a walk accompanied by a knowledgeable adult who will help identify plants and animals.
4. Take a plastic bag with them and collect at least three, but not more than five, different plants.
5. Draw and label a picture of each plant collected in their science journal. Write the plant's native or familiar name.
6. Work with another pair of students (now each group of four has at least six to ten plants) sort the plant samples based upon the group's chosen criteria. (This process repeats with groups of eight, and so on until the whole group is together.)

Reflection and Revision

What additional ways could you sort and classify the plants that you observed? What special characteristic do some plants have that others do not? What special characteristics help each plant to survive in its environment?

Level of Performance

Stage 4: Student work is complete, and shows evidence of logical reasoning. Student collects and classifies four or five plants using three or more attributes (color, size, shape, use, and so on). Drawings are correctly labeled and show correct color, size, and shape for each plant that was collected and classified. Student shows several ways that plants can be organized (in addition to the sorting criteria used in class), and describe several examples of plant adaptation.

Stage 3: Student work is complete, but may contain minor errors or omissions. Student collects and classifies three plants using three or more attributes (color, size, shape, use, and so on). Drawings are labeled and show color, size, and shape for several of the plants that were collected and classified. Student describes one way that plants can be organized (in addition to the sorting criteria used in class), and describe at least one plant adaptation.

Stage 2 — Student work is incomplete or incorrect. Student collects at least two plants and attempts to classify them using some plant attributes (color, size, shape, use, and so on). Drawings show color, size, or shape for one plant that was collected. Student may attempt to describe how to organize plants using a new attribute or may repeat a description of the method used in class. Descriptions of plants and plant adaptations may include misconceptions

Stage 1 — Student work is largely incomplete and incorrect.

Standards Cross-References

National Science Education Standards

Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking. (Page 129)

Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms. (Page 129)

Benchmarks

Some animals and plants are alike in the way they look and in the things they do, and others are very different from one another. (Page 102)

Plants and animals have features that help them live in different environments (Page 102)

Stories sometimes give plants and animals attributes they really do not have (Page 102)

Mini-Unit: Nature Trails

Performance Standard A12, Level 1

Students sort plants and animals into groups using consistent criteria and describe how some characteristics are for the survival of the plant or animal.

Key Concepts and Skills

- There are similarities and differences in plants.
- Plants are classified by different attributes.
- Students can use the processes of science including observation, classification, and communication.

Timeline

2 weeks or longer.

Abstract

This unit focuses on skills of observation and classification that need to take place over and over again in a child's primary education. After observing, collecting, and classifying plants found along nature trails, Students will communicate their findings with their classmates and teacher. Before this mini-unit takes place, students should have previous experiences with sorting and classifying.

Alaska Science Content Standard Key Element

A student who meets the content standard should distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life and understand the theories that describe the importance of diversity for species and ecosystems.

Cross-Reference

Additional Content and Performance Standards: B1, B4, Math C1, Cultural Standards A5, D2

Materials

- ✔ Science journal
- ✔ Hand lens
- ✔ Small plastic bag
- ✔ Clip board
- ✔ Chart paper
- ✔ Pencils, colored pencils, markers

Activities

1

Class will take a nature walk. Prior to going on the walk, students draw what they think they will see, hear, touch, or smell on their walk. Back in the classroom after the walk, students draw what they did see, hear, touch, or smell during the walk. They share their favorite thing drawn and put it on chart paper. Hang in classroom.

Embedded Assessment

Teacher checks the student's science journals when back in the classroom.

2

Go on a sound walk. Listen for man-made sounds. Create a sound map in their science journal by doing the following activity. Each student finds a place to sit or stand where they are not looking at anyone else. Sit quietly for 2–3 minutes. In their science journal mark with an "X" where sound came from in relation to self (in front of, in back of, right, left, above). Then talk about which sounds were heard and where. Do the same sound activity again for 2 minutes. Discuss again.

3

Go on a sight walk outside. Ask a knowledgeable adult to accompany students and help identify plants, animals, and so on. (Try to include a scientist and an Elder knowledgeable in natural uses of plants.) Look for natural things. Do the following camera activity with a partner. One student is the camera, one student is the photographer. The photographer guides the camera (who has kept eyes closed), to the object(s) that the observer wants the camera to focus on. The photographer taps the camera's shoulder, which is the signal for the camera to open its lens (eyes) for a count of ten. Then the camera closes its lens and the pair take 2–3 more pictures. After the pictures are taken, the camera chooses one of the objects focused on and draws a picture with as much detail as possible. Partners switch roles. After both partners are done, find the area the picture was drawn from and observe how much they remembered. Back in the classroom use pictures for a sorting activity.

Expanded Sample Assessment Idea

Students will take a nature walk; observe plant and animal life; collect samples of local plants.

Procedure

Students will:

1. Discuss acceptable ways to collect plants before walk.
2. Form student pairs; go on a walk accompanied by a knowledgeable adult who will help identify plants and animals.
3. Take a plastic bag with them and collect at least three, but not more than five, different plants.
4. Draw and label a picture of each plant collected in their science journal. Write the plants' native or familiar name.
5. Work with another pair of students (now each group of four has at least six to ten plants) sort the plant samples based upon the group's chosen criteria. (This process repeats with groups of eight, and so on until the whole group is together.)

Reflection and Revision

What additional ways could you sort and classify the plants that you observed? What special characteristics do some plants have that others do not? What special characteristic helps each plant to survive in its environment?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student collects and classifies four or five plants using three or more attributes (color, size, shape, use, and so on). Drawings are correctly labeled, and show correct color, size, and shape for each plant that was collected and classified. Student shows several ways that plants can be organized (in addition to the sorting criteria used in class), and describe several examples of plant adaptation.

Stage 3 — Student work is complete, but may contain minor errors or omissions. Student collects and classifies three plants using three or more attributes (color, size, shape, use, and so on). Drawings are labeled, and show color, size, and shape for several of the plants that were collected and classified. Student describes one way that plants can be organized (in addition to the sorting criteria used in class), and describe at least one plant adaptation.

Stage 2 — Student work is incomplete or incorrect. Student collects at least two plants and attempts to classify them using some plant attributes (color, size, shape, use, and so on). Drawings show color, size, or shape for one plant that was collected. Student may attempt to describe how to organize plants using a new attribute or may repeat a description of the method used in class. Descriptions of plants and plant adaptations may include misconceptions.

Stage 1 — Student work is largely incomplete and incorrect.

Standards Cross-References

National Science Education Standards

Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking. (Page 129)

Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms. (Page 129)

Benchmarks

Some animals and plants are alike in the way they look and in the things they do, and others are very different from one another. (Page 102)

Plants and animals have features that help them live in different environments. (Page 102)

Stories sometimes give plants and animals attributes they really do not have. (Page 102)

Alaska Science Key Element A13

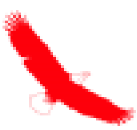
A student who meets the content standard should understand the theory of natural selection as an explanation for evidence of changes in life forms over time (Evolution and Natural Selection).

Performance Standard Level 1, Ages 5–7

Students describe organisms that once lived on Earth, but have completely disappeared.

Sample Assessment Ideas

- Students list three animals that no longer exist on Earth and three animals that now exist.
- Students watch a movie about prehistoric times. Pick out three things that are not true about our Earth today.



Expanded Sample Assessment Idea

- Students use an assortment of pictures or toys, to separate animals that no longer live on Earth from those animals that are now living on Earth.

Procedure

Students will:

1. Study pictures or toys of animals (some that currently live on Earth and some that no longer live on Earth).
2. In a group, sort the animals into those currently living on Earth and those no longer living on Earth.
3. Individually sort a subset of 5 animal pictures or toys into groups of those currently living on Earth and those no longer living on Earth; make a poster using the animal pictures; discuss why they choose to put the animals in each category.

Reflection and Revision

Given 4–5 new animal pictures or toys, how do you decide where they should be placed in the poster?

Level of Performance

Stage 4	Student successfully sorts the animal pictures and the new set of animals.
Stage 3	Student successfully sorts most of the animal pictures and the new set of animals.
Stage 2	Student has limited success sorting the animal pictures or the new set of animals.
Stage 1	Student has difficulty sorting animals pictures and new animals and most are incorrectly sorted.

Standards Cross-References

National Science Education Standards

An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations (Page 129)

Benchmarks

Different plants and animals have external features that help them thrive in different kinds of places. (Page 123)

Some kinds of organisms that once lived on Earth have completely disappeared, although they were something like others that are alive today. (Page 123)

Alaska Science Key Element A14a

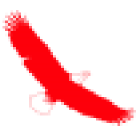
A student who meets the content standard should understand the interdependence between living things and their environments (Interdependence).

Performance Standard Level 1, Ages 5–7

Students identify those things which plants and animals need in order to survive and reproduce.

Sample Assessment Ideas

- Students bring pictures of their favorite local animals to class; draw pictures of different types of foods that those animals eat and places where those animals live.
- Students tell what would happen if a caribou was moved to the desert, or if a crocodile was moved to the Arctic.



Expanded Sample Assessment Idea

- Students collect pictures of the types of birds found in the local area; identify the foods eaten by these birds; group birds according to diet.

Procedure

Students will:

1. Collect pictures of at least three types of birds found in the local area.
2. Discover the types of food used by each bird through observation, reading, and discussion with parents and Elders.
3. Discuss types of food eaten by each bird.
4. In student groups of four, classify the birds according to diet using a Venn diagram.
5. As a class, discuss how the diets are different. Do these birds vary their diets according to season?

Reflection and Revision

What happens to this bird when the food becomes scarce?

Level of Performance

Stage 4 — Student work is complete, correct, detailed, and shows evidence of logical reasoning. Student demonstrates ability to group all of the birds according to diet and describe birds and their foods in great detail.

Stage 3 — Student work is complete, although minor inaccuracies may be present. Student demonstrates ability to group most of the birds according to diet and describe birds and food lists in some detail.

Stage 2 — Student work may be incomplete, show evidence of misconceptions or contain errors of science fact and reasoning. Descriptions of birds and food list are limited and student has difficulty grouping birds

Stage 1 — Student work is largely incomplete, incorrect, shows little evidence of understanding and may contain major misconceptions

Standards Cross-References

National Science Education Standards

Organisms have basic needs For example, animals need air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms. (Page 129)

All animals depend on plants Some animals eat plants for food. Other animals eat animals that eat the plants (Page 129)

Resources are things that we get from the living and non-living environment to meet the needs and wants of a population. (Page 140)

Some resources are basic materials, such as air, water, and soil: some are produced from basic resources, such as food, fuel, and building materials; and some resources are non-material, such as quiet places, beauty, security, and safety. (Page 140)

The supply of many resources is limited. If used, resources can be extended through recycling and decreased use (Page 140)

Benchmarks

Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting. (Page 116)

Living things are found almost everywhere in the world. There are somewhat different kinds in different places (Page 116)

Alaska Science Key Element A14b

A student who meets the content standard should understand that the living environment consists of individuals, populations, and communities (Interdependence).

Performance Standard Level 1, Ages 5–7

Students identify local animals that live together in groups.

Sample Assessment Ideas

- Students describe the interactions within a population of local animals during mating season.
- Students brainstorm a list of animals that live in groups.

Expanded Sample Assessment Idea

- Students make a classroom bulletin board of local animals that live in groups.

Procedure

Students will:

1. Identify different local animals that live in groups; discuss the type of group the animals live in (for example, female groups, mixed groups, groups with leaders, and so on). Collect pictures (from photographs, magazine, Internet) of these animals.
2. Post pictures on bulletin board to form groups of animals.

Reflection and Revision

How does living in a group affect the animal? Does this animal live in a group all the time? Do both sexes of these animals live in the group? Does the group have a leader? Group the animals you have studied in a Venn diagram.

Level of Performance

Stage 4	Student collects multiple animal pictures and correctly identifies the animals and different group types.
Stage 3	Student collects multiple animal pictures and correctly identifies most of the animals.
Stage 2	Student may collect multiple animal pictures but correctly identifies only one or two animals.
Stage 1	Student may collect an animal picture and identify it.

Standards Cross-References

National Science Education Standards

Human populations include groups of individuals living in a particular location. One important characteristic of a human population is the population density-the number of individuals of a particular population that lives in a given amount of space. (Page 140)

The size of a human population can increase or decrease. Populations will increase unless other factors such a disease or famine decreases the population. (Page 140)

Benchmarks

Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting. (Page 116)

Living things are found almost everywhere in the world. There are somewhat different kinds in different places. (Page 116)

Alaska Science
Key Element A14c

A student who meets the content standard should understand that a small change in a portion of an environment may affect the entire environment (Interdependence).

Performance Standard Level 1, Ages 5–7

Students listen to a story (from the past or present) that describes how a shortage or surplus of resources affects the survival of plants and animals.

Sample Assessment Ideas

- Students invite a parent or Elder to tell the class about the worst winter they have experienced, and the affect it had on local wildlife and plants
- Students describe the competing interests, both human and wildlife, during the local berry harvest.

Standards Cross-References

National Science Education Standards

An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations (Page 129)

All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial. (Page 129)

Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans (Page 140)

Benchmarks

Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting. (Page 116)

Living things are found almost everywhere in the world. There are somewhat different kinds in different places. (Page 116)

Alaska Science Key Element A15

A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

Performance Standard Level 1, Ages 5–7

Students identify local landforms and resources

Sample Assessment Ideas

- Students name local landforms and landmarks (mountains, river systems).
- Students make a bulletin board or poster identifying local plants, animals, and the locations where they can be found.
- Students construct landforms out of clay or paper maché.

Standards Cross-References

National Science Education Standards

Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms. (Page 129)

Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms. (Page 129)

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants. (Page 129)

Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use. (Page 134)

Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation. (Page 134)

Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population. (Page 140)

Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans. (Page 140)

Benchmarks

Some events in nature have a repeating pattern. The weather changes some from day to day but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year. (Page 67)

Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing. (Page 67)

Chunks of rocks come in many sizes and shapes, from boulders to grains of sand and even smaller. (Page 72)

Change is something that happens to many things. (Page 72)

Animals and plants sometimes cause changes in their surroundings. (Page 72)

Some animals and plants are alike in the way they look and in the things they do, and others are very different from one another. (Page 102)

Plants and animals have features that help them live in different environments. (Page 102)

Stories sometimes give plants and animals attributes they really do not have. (Page 102)

There is variation among individuals of one kind within a population. (Page 107)

Animals eat plants or other animals for food and may also use plants (or even other animals) for shelter and nesting. (Page 116)

Alaska Science Key Element A16

A student who meets the content standard should understand basic concepts about the theory of relativity, which changed the view of the universe by uniting matter and energy and by linking time with space (Relativity).

Performance Standard Level 1, Ages 5–7

There is no performance standard at this level.

Alaska Science Content Standard B

Level 1, Ages 5–7

A student should possess and understand the skills of scientific inquiry.

Alaska Science Key Element B1

A student who meets the content standard should use the processes of science; these processes include observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

Performance Standard Level 1, Ages 5–7

Students observe and describe their world.

Sample Assessment Ideas

- Students closely observe an object (rock, flower, animal) closely with as many of the five senses as appropriate; list characteristics observed with each sense
- Students observe and predict sunrise from a specific site (for example; classroom window, playground) and chart data daily.

Expanded Sample Assessment Idea

- Students use a "teacher-created" scoring guide to classify a group of rocks and tell why the rocks were grouped in that manner

Procedure

Students will:

1. Collect rocks at home and school.
2. Divide into groups of two to three; take a group of 8–12 rocks and classify them by criteria of their group's choosing. This could include color, size, shape, texture, use, etc. Groups will share with each other the ways they classified the rocks. Each group will then go back and create a different way to classify their rock. Each group should guess the other groups' new classification.
3. Draw how their group classified a rock of their choice and include details like color, shape, and size.
4. Discuss volunteers' pictures in circle group.

Reflection and Revision

Use comments about pictures and redraw their rock classification.

Level of Performance

Stage 4 — Student work is correct, complete, and appropriate. Student work includes detailed explanations of their two classification systems. There is no evidence of misconceptions or inaccurate descriptions; drawings have accurate colors and realistic size

Stage 3 — Student work is generally correct, complete, and appropriate including two classification systems of rocks. Student explanations of classification systems are accurate. Drawings may show a few inaccuracies or unrealistic descriptions of the actual rocks.

Stage 2 — Student classifications are mostly appropriate, but there may be some misconceptions. Student cannot explain classifications. Drawings are incomplete. There is little evidence of elaboration or extensions.

Stage 1 — Student did not complete classifications and could not tell why. No drawings completed. There is no evidence of elaboration or extensions. There is evidence of misconceptions

Standards Cross-References

National Science Education Standards

Employ simple equipment and tools to gather data and extend the senses. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations. (Page 122)

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Simple instruments such as magnifiers, thermometers, and rulers provide more information than scientists obtain using only their senses. (Page 123)

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. (Page 10)

Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained just by observing things without their help. (Page 10)

Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others. (Page 10)

Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question. (Page 298)

Mini-Unit: Rock On

Performance Standard B1, Level 1

Students observe and describe their world.

Key Concepts and Skills

- There are similarities and differences in nature.
- Measurement can be done in a variety of ways.
- Students can use the processes of science including observation, classification, measurement, and prediction.
- Rocks come in many sizes and shapes

Timeline

This can take place over two or three weeks.

Abstract

Students observe and measure rocks in order to classify and infer usage from their characteristics

Alaska Science Content Standard Key Element

A student who meets the content standard should use the processes of science; these processes include observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

Cross-Reference

Additional Content and Performance Standards: A7, Geography E1, Math A2, E2, E3.
Cultural Standards: D1, D5

Materials

- ✔ Collection of rocks (local, purchased, or AMEREF Minerals Kit)
- ✔ Assorted materials to use when designing tools
- ✔ Equal-arm balances
- ✔ Chart paper
- ✔ Markers
- ✔ Graph paper (1" squares)
- ✔ Yarn or hoops
- ✔ Small plastic bears, unifix or wooden cubes, tiles, etc.
- ✔ White paper
- ✔ Hand lens or magnifiers

Activities

1

Teacher brings in a box of assorted rocks. Students play “20 Questions” about the contents of the box. After contents are guessed, the rocks are distributed among students and they observe the rocks using their eyes, hands, lenses or magnifiers. Ask students such things as how are they alike, how are they different, what words would you use to describe the rocks? Record responses on chart paper for class to see. Place rocks in a science center in the classroom.

2

Teacher has whole class gather around and places 16–20 assorted rocks in a pile on a piece of paper. Have a student choose an attribute such as small. Move all the small rocks into a pile, label it small, and draw a circle around it. Place the other rocks in a pile, draw a circle around it and label it not small. Keep dividing the piles using properties (shiny, not shiny; rough, not rough; heavy, not heavy) until you have used all the rocks you started with. Give each student group (three to four students) 16–20 rocks. Ask them to create their own classification system. *This is an example of binary classification. (*As students are grouping their rocks, the teacher walks around with a checklist to assess how students are doing with their classifying skills. Any type of classification should be accepted as long as the student can justify it.)

3

Ask a student to choose 10 rocks that have several attributes and bring them from the science center to a place that has a Venn diagram set up (a Venn diagram can be created by using yarn or plastic hoops). Students gather around and together they will choose two rules to sort the rocks (like big and jagged). Write the rules on a folded piece of paper that can be placed in the circles. Students decide where to place the 10 rocks according to the rules. Ask students what they notice about the rocks in each circle. Guide them if necessary to the conclusion that some rocks fit both of the rules and should be placed in both circles. Ask how a rock could be in both circles at the same time. If students do not come up with moving the circles, begin to overlap them. Spend some time asking questions that lead to student understanding of the “intersection” of both circles. When students have an understanding, ask them to place the rocks according to the chosen rules. Repeat this again and again choosing different attributes to use in sorting. (This is another opportunity for teachers to do a short check to find out at what level students can use a Venn diagram.)

“The edge of the rock look like a hill with a little valley.”
C.B.

4

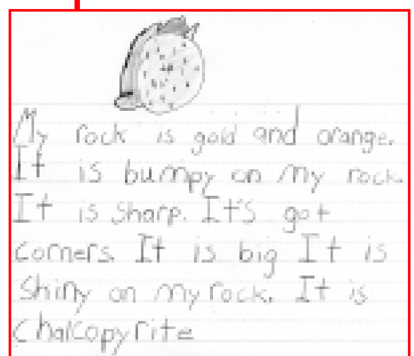
Students will look at specific attributes of rocks and use them to sequence the rocks (e.g., lightest to darkest; smallest to largest). Students begin with three rocks and then work up to using five rocks. Students use a gold dredge worksheet like the one below to draw their rock sequence.

5

Give students graph paper with at least one-inch squares. Tell them to choose a rock and place it on the paper. Ask students how many squares big their rock is. Students choose three more rocks to repeat the procedure.

6

Choose two or three students to come up in front of the class and hold two different size rocks. Ask which rock is heavier? How they can tell? Ask the students if they know of other ways to measure how much things weigh. (Hopefully they will come up with using balances). Provide students with an equal-arm balance and cubes, bears, tiles, etc., that they can measure. Students will weigh three to five different items and record their findings.



J.A. describes her rock, using three attributes.

7

Brainstorm ways that rocks could be used by people and animals. Chart the ideas given by the students. Invite community people to come into the classroom to discuss traditional uses of rocks (e.g., communication, tools, fishing, hunting, etc). Using their knowledge of rock characteristics, students investigate and design a tool using a rock. Display student work.

Expanded Sample Assessment Idea

Procedure

Students will:

1. Collect rocks at home and school.
2. Divide into groups of two to three; take a group of 8–12 rocks and classify them by criteria of their group's choosing. This could include color, size, shape, texture, use, and so on. Groups will share with each other the ways they classified the rocks. Each group will then go back and create a different way to classify their rocks. Each group should guess the other groups' new classification.
3. Draw how their group classified a rock of their choice and include details like color, shape, and size.
4. Discuss volunteers' pictures in circle group.

Reflection and Revision

Use comments about pictures and redraw their rock classification.

Level of Performance

Stage 4 — Student work is correct, complete and appropriate. Student work includes detailed explanations of their two classification systems and are detailed. There is no evidence of misconceptions or inaccurate descriptions; drawings have accurate colors and realistic size

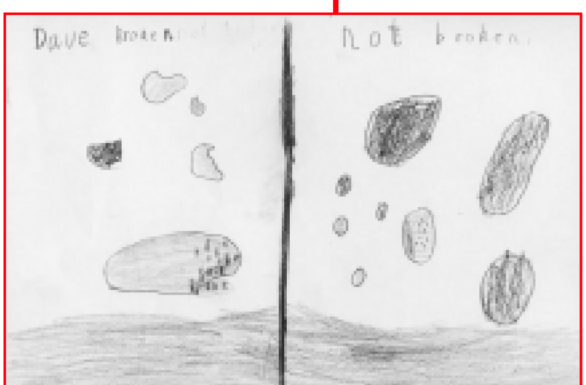
Stage 3 — Student work is generally correct, complete, and appropriate including two classification systems of rocks. Student explanations of classification systems are accurate. Drawings may show a few inaccuracies or unrealistic descriptions of the actual rocks.

Stage 2 — Student classifications are mostly appropriate, but there may be some misconceptions. Student could not explain classifications. Drawings are incomplete. There is little evidence of elaboration or extensions.

Stage 1 — Student did not complete classifications and could not tell why. No drawings completed. There is no evidence of elaboration or extensions. There is evidence of misconceptions.

Standards Cross-References

National Science Education Standards



Employ simple equipment and tools to gather data and extend the senses. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations. (Page 122)

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Simple instruments such as magnifiers, thermometers, and rulers provide more information than scientists obtain using only their senses. (Page 123)

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. (Page 10)

Tools such as thermometers, magnifiers, rulers, or balances often give more information about things than can be obtained just by observing things without their help. (Page 10)

Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others. (Page 10)

Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question. (Page 298)

Level 1

Alaska Science Key Element B2

A student who meets the content standard will design and conduct scientific investigations using appropriate instruments

Performance Standard Level 1, Ages 5–7

Students use appropriate measuring and observation instruments to explore the natural world around them.

Sample Assessment Ideas

- Students use a magnifying glass to observe an object (e.g., rock, bug, hair, skin, plant); draw a picture to describe how the object looks different compared to viewing with only their eyes
- Students weigh and measure a salmon or other meat before and after smoking in a smokehouse. Compare the data from before and after smoking.

Expanded Sample Assessment Idea

- Students investigate how a change in environment affects a plant's growth. Changes might include amount of light, water, soil type, etc.

Procedure

(Allow four weeks.)

Students will:

1. Each receive a newly potted plant.
2. Divide into three groups: Group 1 will water their plants one day per week. Group 2 will water their plants two days per week. Group 3 will water their plants three days per week (each group will use the same amount of water).
3. Record daily observations (amount of water added, changes in appearance, and measurements of height or diameter).
4. Develop their thoughts as to how and why their plants grew the way they did.
5. Make graphs comparing growth rates
6. Make predictions about what is needed to grow healthy plants.
7. Discuss what instruments they used for measuring the amount of light, water and plant growth. Discuss differences between the groups

Reflection and Revision

Record the optimum conditions for growing plants in their science journal.

Level of Performance

Stage 4 — Student work is complete, correct, and shows higher-order thinking skills and relevant knowledge. Measurements are accurate, instruments are chosen without teacher prompt and are used appropriately.

Stage 3 — Student work is generally complete and correct. Measurements are accurate and instruments are used appropriately. There may be some evidence of misconceptions or discrepancies between journal entries and actual observations

Stage 2 — Student work is mostly incomplete or incorrect. While an attempt was made to grow plants, measurements and observations are inaccurate or incomplete The student is able to choose correct measuring instruments following teacher prompts.

Stage 1 — Student work is incomplete and incorrect. Attempts to grow plants, if made, do not include measurements or recorded observations.

Standards Cross-References

National Science Education Standards

Plan and conduct a simple investigation. In the earliest years, investigations are largely based on systematic observations (Page 122)

Employ simple equipment and tools to gather data and extend the senses In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations (Page 122)

Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (Page 123)

Simple instruments such as magnifiers, thermometers, and rulers provide more information than scientists can obtain using only their senses (Page 123)

Benchmarks

People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. (Page 10)

Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. (Page 285)

Alaska Science Key Element B3

A student who meets the content standard should understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

Performance Standard Level 1, Ages 5–7

Students ask questions about the natural world.

Sample Assessment Ideas

- Students develop "I wonder" statements about snow
- Students generate a list of questions about their local environment to ask a guest scientist or local Elder

Standards Cross-References

National Science Education Standards

Ask a question about objects, organisms, and events in the environment. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations. (Page 122)

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Benchmarks

When people give different descriptions of the same thing, it is usually a good idea to make some fresh observations instead of just arguing about who is right. (Page 10)

Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. (Page 285)

Alaska Science Key Element B4

A student who meets the content standard should understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort, and logical reasoning are all aspects of scientific inquiry.

Performance Standard Level 1, Ages 5–7

Students collaborate to investigate the natural world.

Sample Assessment Ideas

- Students share observations while on a class field trip to investigate local plant and animal life
- Students observe, record, and discuss living and non-living components of their school.

Expanded Sample Assessment Idea

- Students work in groups to predict and test which objects float and which objects sink in water

Procedure

Students will:

1. Divide into small groups
2. Have access to a variety of measuring tools and large container of water with measurements on the side
3. Predict which objects will sink and which will float. Record predictions on a chart paper. Do not change predictions after observations are made
4. Select items to put into the water one at a time
5. Record whether they sink or float.
6. Make a picture or word chart of the results and share with the whole class
7. As a class, discuss how the groups worked together, what new things they learned, and which charts worked best to explain sinking and floating.

Reflection and Revision

Discuss how they would change their work from what they learned from others

Level of Performance

Stage 4 — Student work is complete, correct and shows evidence of elaboration, extension, collaboration and creative incorporation of the ideas of others.

Stage 3 — Student work is generally complete, correct and shows some evidence of elaboration, extension, collaboration or incorporation of the ideas of others.

Stage 2 — Student work may be incomplete or incorrect and shows some evidence of sharing of ideas, but limited evidence of collaboration or incorporation of the ideas of others.

Stage 1 — Student work, although incomplete, is on topic but shows no evidence of collaboration or sharing of ideas.

Standards Cross-References

National Science Education Standards

Ask a question about objects, organisms, and events in the environment. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations. (Page 122)

Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (Page 123)

Benchmarks

In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean. (Page 15)

Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. (Page 285)

Alaska Science Key Element B5

A student who meets the content standard should employ ethical standards, including unbiased data collection and factual reporting of results.

Performance Standard Level 1, Ages 5–7

Students differentiate between what they observe with their senses and what they interpret about those observations

Sample Assessment Ideas

- Students touch a dry sock and a wet sock; measure the temperature of each; report on whether or not they are the same temperature; discuss the accuracy of their interpretation.
- Students observe a bird, squirrel, or class pet; make a chart of their observations and interpret their behavior.

Expanded Sample Assessment Idea

- Students identify an object in a black box using only one sense; share observations with other students who used other senses; compare conclusions about the nature of the object using single vs multiple senses to observe

Procedure

Students will:

1. Divide into sensory groups: smell, touch, and hearing.
2. Explore objects (such as seaweed, jerky, mashed berries) using only one sense; no one will see or taste it.
3. Reorganize so that each new group contains a child who used a different sense. Repeat so that each group will have each sense represented.
4. Share the observations, try to identify the object, and differentiate between observations and inferences

Reflection and Revision

Determine what senses provided the most accurate inferences about the identification of the objects

Level of Performance

Stage 4 — Student work is complete, correct and shows evidence of elaboration and extension. Students report detailed observations and inferences and differentiation between the two.

Stage 3 — Student work is generally complete, correct and may show evidence of elaboration and extension. Students report observations and inferences and differentiation between the two though minor errors may be present.

Stage 2 — Student work may be incomplete or incorrect and shows limited evidence of ability to report observations, make inferences or differentiate between the two.

Stage 1 — Student work is mostly incomplete and incorrect. Student makes limited observations or is unable to use observations to identify the object in the black box.

Standards Cross-References

National Science Education Standards

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations (Page 123)

Scientists review and ask questions about the results of other scientists' work. (Page 123)

Benchmarks

A lot can be learned about plants and animals by observing them closely, but care must be taken to know the needs of living things and how to provide for them in the classroom. (Page 15)

Alaska Science Key Element B6

A student who meets the content standard should employ strict adherence to safety procedures in conducting scientific investigations

Performance Standard Level 1, Ages 5–7

Students learn classroom safety procedures, identify consequences of unsafe behavior, and practice safe behavior in the classroom and laboratory.

Sample Assessment Ideas

- Students practice safety rules during classroom and laboratory activities.
- Students identify features of the classroom that promote safety (e.g., fire extinguisher, smoke detectors, no sharp edges, etc.); record observations on chart paper.

Standards Cross-References

National Science Education Standards

Safety and security are basic needs of humans. Safety involves freedom from danger, risk, or injury. Security involves feelings of confidence and lack of anxiety and fear. Student understandings include following safety rules for home and school, preventing abuse and neglect, avoiding injury, knowing whom to ask for help, and when and how to say no. (Page 139)

Benchmarks

Choices have consequences, some of which are more serious than others. (Page 165)

Rules at home, at school, and in the community let individuals know what to expect and so can reduce the number of disputes. (Page 172)

Alaska Science Content Standard C

Level 1, Ages 5–7

A student should understand the nature and history of science.

Alaska Science Key Element C1

A student who meets the content standard should know how the words "fact," "observation," "concept," "principle," "law," and "theory" are generally used in the scientific community.

Performance Standard Level 1, Ages 5–7

Students will use observations to collect and identify facts.

Sample Assessment Ideas

- Students observe and record what birds choose from a variety of materials provided for them as potential food sources (e.g. wood chips, bird seed, bread, cotton balls, etc.)
- Students observe that some things around them happen consistently (water flows downhill, heating ice causes it to melt.)

Standards Cross-References

National Science Education Standards

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question. (Page 298)

Alaska Science Key Element C2

A student who meets the content standard should understand that scientific knowledge is validated by repeated specific experiments that conclude in similar results

Performance Standard Level 1, Ages 5–7

Students will compare observations and/or repeat observations to check for validity of results.

Sample Assessment Ideas

- Students observe unpainted structures made of wood (e.g., sheds, fences); discuss the occurrence of wood shrinkage.
- Students observe a phenomenon which repeats itself regularly (e.g., dropped ball bounces at a lower height with each successive bounce); compare results with other students for validation.

Standards Cross-References

National Science Education Standards

Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (Page 123)

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations (Page 123)

Scientists review and ask questions about the results of other scientists' work. (Page 123)

Benchmarks

When a science investigation is done the way it was done before, we expect to get a very similar result. (Page 6)

Science investigations generally work the same way in different places (Page 6)

Alaska Science Key Element C3

A student who meets the content standard should understand that society, culture, history, and environment affect the development of scientific knowledge

Performance Standard Level 1, Ages 5–7

Students recite a traditional story describing a scientific event.

Sample Assessment Ideas

- Students recite a traditional story lore describing the breaking up of the ice during spring.
- Students recite a traditional story that explains the salmon runs

Standards Cross-References

National Science Education Standards

Science and technology have been practiced by people for a long time. (Page 141)

Men and women have made a variety of contributions throughout the history of science and technology. (Page 141)

Benchmarks

Everybody can do science and invent things and ideas. (Page 15)

Alaska Science Key Element C4

A student who meets the content standard should understand that some personal and societal beliefs accept non-scientific methods for validating knowledge.

Performance Standard Level 1, Ages 5–7

Students observe a phenonmenon and record a personal (non-scientific) belief about that phenomenon.

Sample Assessment Ideas

- Students observe the sky when the sun, moon and stars are not visible and state their opinion regarding what they see.
- Students observe animal behavior and state their belief about reasons behind the behavior.

Standards Cross-References

National Science Education Standards

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Page 138)

Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished. (Page 141)

Benchmarks

Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question. (Page 298)

Alaska Science Key Element C5

A student who meets the content standard should understand that sharing scientific discoveries is important to influencing individuals and society and in advancing scientific knowledge.

Performance Standard Level 1, Ages 5–7

Students work together to explore and share scientific discoveries about their environment.

Sample Assessment Ideas

- Students work together in teams to explore the playground environment; look for conditions that support a suitable habitat for living things; collectively share results with the class
- Students teams report on weather observations; as a class make predictions using the class data.

Standards Cross-References

National Science Education Standards

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations (Page 123)

Scientists review and ask questions about the results of other scientists' work. (Page 123)

Benchmarks

In doing science, it is often helpful to work with a team and to share findings with others. All team members should reach their own individual conclusions, however, about what the findings mean. (Page 15)

Alaska Science Key Element C6

A student who meets the content standard should understand that scientific discovery is often a combination of an accidental happening and observation by a knowledgeable person with an open mind.

Performance Standard Level 1, Ages 5–7

Students share information about their world that they have learned though observation.

Sample Assessment Ideas

- Students describe how they learned to ride a bike, ride a sled, catch a fish, etc
- Students compare the number of teeth each student has lost.

Standards Cross-References

National Science Education Standards

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

People can often learn about things around them just by observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. (Page 10)

Level 1

Alaska Science Key Element C7

A student who meets the content standard should understand that major scientific breakthroughs may link large amounts of knowledge, build upon the contributions of many scientists, and cross different lines of study.

Performance Standard Level 1, Ages 5–7

Students examine inventions and describe the human efforts required to produce it.

Sample Assessment Ideas

- Students examine a traditional Tlingit halibut hook and modern circular hook; discuss which hook is easier to use to catch plastic fish; discuss how each hook is made
- Students pick a tool or machine from *How Things Work* by David McCauley; report its use to the class

Standards Cross-References

National Science Education Standards

Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (Page 123)

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Page 138)

Benchmarks

Everybody can do science and invent things and ideas. (Page 15)

Level 1

Alaska Science Key Element C8

A student who meets the content standard should understand that acceptance of a new idea depends upon supporting evidence and that new ideas that conflict with beliefs or common sense are often resisted.

Performance Standard Level 1, Ages 5–7

Students observe and discuss phenomena that conflict with common sense

Sample Assessment Ideas

- Students discover the answer to the question “When is a jar full?” Fill a jar with small rocks; ask the question, “Is the jar full?”; add gravel to jar and shake; ask, “Is the jar full?”; repeat process using sand and finally water.
- Students view, predict length, and then measure the true length of various optical illusions

Expanded Sample Assessment Idea

- Students describe their common-sense impressions regarding equal volumes of water placed in differently shaped containers; identify evidence that supports the idea that the volumes of water involved are equal.

Procedure

Students will:

1. Divide into teams
2. Observe containers of different shapes that contain (unbeknownst to them) equal volumes of water.
3. Describe their impressions about which containers contain the most and least water.
4. Arrange containers from perceived largest to smallest volumes of water.
5. Use a measuring container to establish that the volume of water in each container is equal to the volume in any other.
6. Pour the contents of containers back and forth between each other.

Refection and Revision

Discuss the evidence supporting the idea that the volumes of water in all containers were equal.

Level of Performance

Stage 4 — Student participates fully, makes accurate observations, demonstrates mastery of concepts and skills, clearly describes and communicates findings, and relates conclusions to other processes and concepts. Student participates fully in class discussion, clearly describes and communicates findings and concludes the activity without evidence of misconceptions regarding the volume of water.

Stage 3 — Student participates substantially, makes largely accurate observations, understands the concepts and skills, and effectively describes and communicates findings and conclusions. Student participates in class discussion, describes and communicates findings but may conclude the activity with minor misconceptions regarding the volume of water.

Stage 2 — Student participates, makes observations, grasps the concepts and skills, and attempts to describe and communicate findings and conclusions. Student is a reluctant participant in class discussion and although an attempt is made to describe the findings, the student concludes the activity with misconceptions regarding the volume of water.

Stage 1 — Student minimally participates, gives inaccurate observations, does not grasp the concepts and skills. Student does not participate in class discussion or describe the findings and concludes the activity with major misconceptions regarding the volume of water.

Standards Cross-References

National Science Education Standards

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

When people give different descriptions of the same thing, it is usually a good idea to make some fresh observations instead of just arguing about who is right. (Page 10)

Alaska Science Content Standard D

Level 1, Ages 5–7

A student should be able to apply scientific knowledge and skills to make reasoned decisions about the use of science and scientific innovations.

Alaska Science Key Element D1

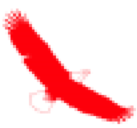
A student who meets the content standard should apply scientific knowledge and skills to understand issues and everyday events.

Performance Standard Level 1, Ages 5–7

Students use science knowledge to describe everyday events.

Sample Assessment Ideas

- Students tell why it is easier to make snowballs in the spring than in the winter.
- Each student observes where the snow remains on the playground in the spring; give possible scientific explanations as to why the snow is still there.



Expanded Sample Assessment Idea

- Students test three sleds to determine which travels the greatest distance.

Procedure

Students will:

1. Hold the sled at the top of an incline, another student rides the sled, and a third student at the bottom of the hill measures the distance. The same student should ride the sled for each trip down the incline.
2. Measure, record and graph the distance traveled by the sled. Repeat experiment with each sled.
3. Use simplified language to discuss friction, motion and force.
4. Relate this activity to another similar activity, such as sliding down the playground slide, and so on.

Reflection and Revision

Discuss factors other than the sled design that would increase the distance traveled by the sled. Repeat experiment using these factors.

Level of Performance

Stage 4 — Student work is complete, correct, and contains evidence of elaboration, extension, higher order thinking skills, and relevant knowledge. Student actively participates with group to perform an accurate test that considers several factors that may affect the distance traveled by the sled.

Stage 3 — Student work is generally complete and correct but may contain evidence of some inaccuracies or omissions. Student participates with group to perform an accurate test to determine the distance traveled by the sled. Multiple factors are not considered.

Stage 2 — Student work may be incomplete or inaccurate. Student may be a reluctant group participant. The test may include three types of sleds but does not control the variables or make accurate measurements.

Stage 1 — Student work is incomplete and inaccurate. Student does not participate in group task or participates in group sledding adventure rather than testing the sleds.

Standards Cross-References

National Science Education Standards

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strengths of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Page 138)

Some objects occur in nature; others have been designed and made by people to solve human problems and enhance the quality of life. (Page 138)

Benchmarks

People can often learn about things around them just by observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens. (Page 10)

Level 1

Alaska Science Key Element D2

A student who meets the content standard should understand that scientific innovations may affect our economy, safety, environment, health, and society and that these effects may be short-term or long-term, positive or negative, and expected or unexpected.

Performance Standard Level 1, Ages 5–7

Students role-play and discuss the positive and negative consequences of a single scientific or technological event.

Sample Assessment Ideas

- Students role-play a small community where only one family has an automobile.
- Students discuss the positive and negative effects of mosquito repellent.

Standards Cross-References

National Science Education Standards

People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems (Page 138)

People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people. (Page 140)

Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world. (Page 141)

Benchmarks

Tools are used to do things better or more easily and to do some things that could not otherwise be done at all. In technology, tools are used to observe, measure, and make things. (Page 44)

People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life. (Page 54)

Alaska Science Key Element D3

A student who meets the content standard should recommend solutions to everyday problems by applying scientific knowledge and skills

Performance Standard Level 1, Ages 5–7

Students propose and discuss solutions to simple problems

Sample Assessment Ideas

- Students discuss possible solutions to reduce the mud brought into the classroom during the spring.
- Students propose ways to prevent a snowball brought in from the playground from melting.

Standards Cross-References

National Science Education Standards

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Page 138)

Identify a simple problem. In problem identification, children should develop the ability to explain a problem in their own words and identify a specific task and solution related to the problem. (Page 137)

Propose a solution. Students should make proposals to build something or get something to work better; they should be able to describe and communicate their ideas. Students should recognize that designing a solution might have constraints, such as cost, materials, time, space, or safety. (Page 137)

Benchmarks

People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life. (Page 54)

Alaska Science Key Element D4

A student who meets the content standard should evaluate the scientific and social merits of solutions to everyday problems

Performance Standard Level 1, Ages 5–7

Students describe simple technology used in everyday life

Sample Assessment Ideas

- Students evaluate the effectiveness of different ways to keep their coats closed (e.g., Velcro, zipper, snaps, ties, etc.); chart their observations
- Students describe ways to get to school (e.g., bus, bicycle, car, sled, etc.); chart their effectiveness

Standards Cross-References

National Science Education Standards

Evaluate a product or design. Students should evaluate their own results or solutions to problems, as well as those of other children, by considering how well a product or design met the challenge to solve a problem. When possible, students should use measurements and include constraints and other criteria in their evaluations. They should modify designs based on the results of evaluations. (Page 137)

People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems (Page 138)

Tools help scientists make better observations, measurements, and equipment for investigations. Tools help scientists see, measure, and do things that they could not otherwise see, measure, and do. (Page 138)

People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people. (Page 140)

Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world. (Page 141)

Benchmarks

People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life. (Page 54)

When a group of people wants to build something or try something new, they should try to figure out ahead of time how it might affect other people. (Page 54)

Alaska Science Key Element D5

A student who meets the content standard should participate in reasoned discussions of public policy related to scientific innovation and proposed technological solutions to problems.

Performance Standard Level 1, Ages 5–7

Students discuss how tools are used to observe, measure, and make things that help us.

Sample Assessment Idea

- Students describe a tool that they use: what the important characteristics the tool must have; what different jobs the tool can be used for; why each tool is best at doing its job; why different materials are used to make each part of the tool; what are some tools they use at home; their parents use at home; used every day; used only in one season; only used in the morning or evening.
- Students discuss their preferences using a spoon or a fork to eat peas.

Standards Cross-References

National Science Education Standards

People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems (Page 138)

People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people. (Page 140)

Benchmarks

When a group of people wants to build something or try something new, they should try to figure out ahead of time how it might affect other people (Page 54)

Alaska Science Key Element D6

A student who meets the content standard should act upon reasoned decisions and evaluate the effectiveness of the action.

Performance Standard Level 1, Ages 5–7

Students retell examples of consequences that have resulted from their actions.

Sample Assessment Ideas

- Students discuss why or why not to put their tongues on the metal playground equipment during the winter.
- Students discuss why they wear hats and mittens or gloves outside during cold weather. Discuss their past experience.

Standards Cross-References

National Science Education Standards

People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people. (Page 140)

Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms. (Page 129)

Benchmarks

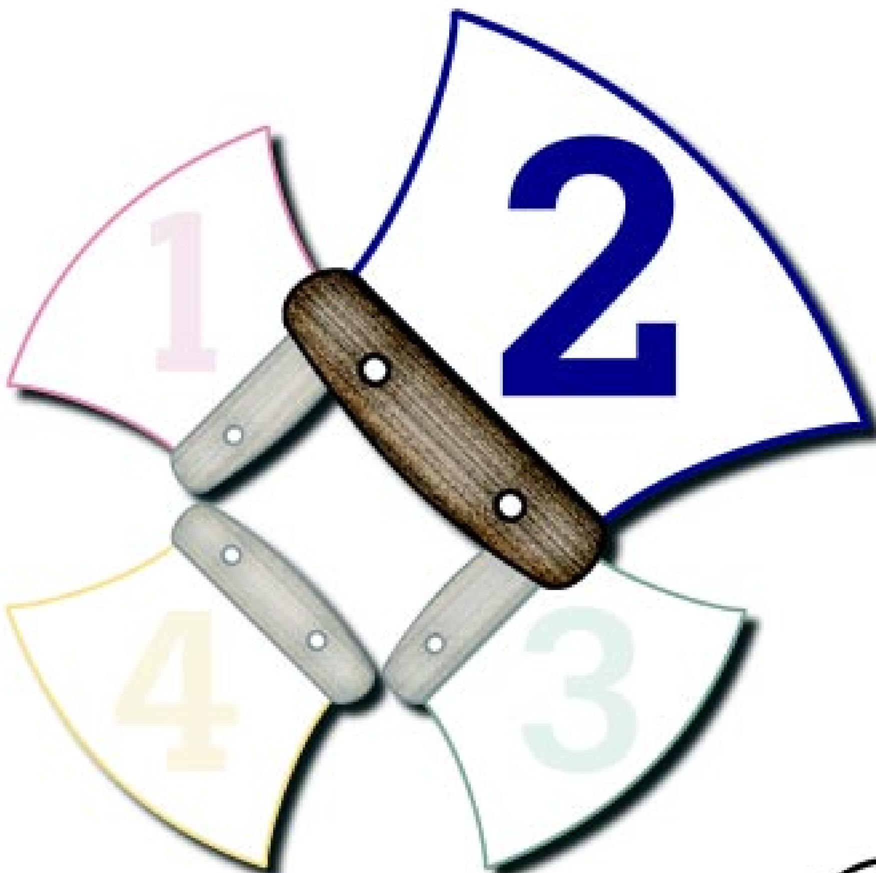
People, alone or in groups, are always inventing new ways to solve problems and get work done. The tools and ways of doing things that people have invented affect all aspects of life. (Page 54)

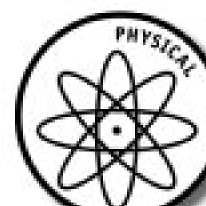
When a group of people wants to build something or try something new, they should try to figure out ahead of time how it might affect other people. (Page 54)

Translating Standards to Practice

A Teacher's Guide to Use and Assessment of the Alaska Science Standards

LEVEL 2, Ages 8–10





Alaska Science Content Standard A

Level 2, Ages 8–10

A student should understand scientific facts, concepts, principles, and theories.

Alaska Science Key Element A1

A student who meets the content standard should understand models describing the nature of molecules, atoms, and sub-atomic particles and the relation of the models to the structure and behavior of matter (Structure of Matter).

Performance Standard Level 2, Ages 8–10

Students use models to represent matter as solids, liquids or gases and the changes from one state to another

Sample Assessment Ideas

- Students investigate snowflakes and different types of snow with a hand lens; draw the differences seen between snowflakes in a journal; investigate the properties of snow using various tools; discuss the "Dillingham Story"; learn several Alaska Native words that describe the different types of snow.
- Students make a model of the water cycle, including water as a solid (snow), a liquid (rain), and a gas (water evaporated into the air).

Expanded Sample Assessment Idea

- Students place an ice cube in a beaker and observe over several days; draw picture to show what happens

Procedure

Students will:

1. Compare ice cubes placed in open and covered beakers in the classroom.
2. Make drawings and notes in a journal over several days.
3. Make an oral report or write a poem to describe what happens to the water.

Revision and Reflection

Explain why the two beakers looked different after several days. Would the results be different if you used water instead of ice? What would happen if you used a cloth to cover the beaker?

Levels of Performance

Stage 4 — Student work is complete, correct and shows evidence of logical reasoning. Several detailed journal entries compare the contents of the two beakers and what happens to the water in the open beaker. The report or poem shows extensive evidence of the transfer and extension of knowledge. The description of the changes from ice to water vapor are accurate and include detailed predictions of how changes in the experimental conditions would alter the observations.

Stage 3 — Student work is complete but may contain minor errors or omissions. Several journal entries compare the two beakers and what happens to the water in the open beaker. The report or poem shows some evidence of the transfer and extension of knowledge. The description of the changes from ice to water vapor are mostly accurate and include a prediction of how a change in an experimental condition would alter the observations.

Stage 2 — Student work may show evidence of skilled craftsmanship but may be incomplete, shows evidence of limited understanding or misconceptions related to what happens as ice changes to water vapor. At least one journal entry is made. The report or poem may describe the two beakers, but the explanation or prediction, if included, may be incorrect.

Stage 1 Student work is mostly incomplete and shows little or no evidence of understanding and misconceptions related to what happens as ice changes to water vapor

Standards Cross-References

National Science Education Standards

Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanations on what they observed and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. (Page 145)

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating and cooling. (Page 127)

Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food.

Earth materials provide many of the resources that humans use. (Page 134)

Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply. (Page 134)

Benchmarks

Seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it. (Page 268)

No matter how parts of an object are assembled, the weight of the whole object made is always the same as the sum of the parts; and when a thing is broken into parts, the parts have the same total weight as the original thing. (Page 77)

Materials may be composed of parts that are too small to be seen without magnification. (Page 77)

Alaska Science Key Element A2

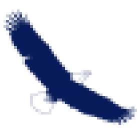
A student who meets the content standard should understand the physical, chemical, and nuclear changes and interactions that result in observable changes in the properties of matter (Changes and Interactions of Matter).

Performance Standard Level 2, Ages 8–10

Students observe physical and chemical properties of common substances and observe changes to those properties.

Sample Assessment Ideas

- Students mix baking soda and vinegar; observe and describe changes in journal.
- Students dissolve rock salt in water, evaporate and re-crystallize; draw and describe their observations.



Expanded Sample Assessment Idea

- Students develop a strategy to sink an ice cube.

Procedure

Students will:

1. Predict if they can sink an ice cube.
2. Work in teams to develop a strategy to make the ice sink.
3. Demonstrate their ice-sinking apparatus; share strategies and observations with the class.

Reflection and Revision

Why is ice so hard to sink? Discuss the properties of ice and water (what they look like, feel like, smell like, taste like and how they behave in relation to sinking and floating.) How are these two forms of water alike and how are they different? Discuss density.

Levels of Performance

Stage 4: Student work is complete, correct, shows evidence of logical reasoning and transfer and extension of knowledge related to the physical properties of the three states of water. Explanation of water's change of state includes correct terminology, physical properties of each state of water, a description of where each phase occurs in nature, and an example of how each change in the state of water affects the local community. The student describes a detailed strategy to sink an ice cube or explains why it isn't possible.

Stage 3: Student work shows evidence of logical reasoning and transfer of knowledge related to the physical properties of the three states of water, but may contain minor errors or omissions. Student explanation of water's change of state includes correct terminology, physical properties of some of the states of water, some descriptions of where water occurs in nature and at least one example of how a change in the state of water affects the local community. The student describes a strategy to sink an ice cube.

Stage 2: Student work contains omissions or errors of science fact and reasoning. Student explanation of water's change of state may identify an example of where water occurs in nature, describes an example of how water is used within the local community, uses some appropriate terminology, and may describe some physical properties of water in one of its three states. A strategy to sink an ice cube, if included, may be incomplete or lack detail.

Stage 1 — Student explanation of the change of state of water is largely incomplete, incorrect, and shows little evidence of understanding the role of water in the local community.

Standards Cross-References

National Science Education Standard

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. These properties can be measured using tools, such as rulers, balances, and thermometers. (Page 127)

Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. (Page 127)

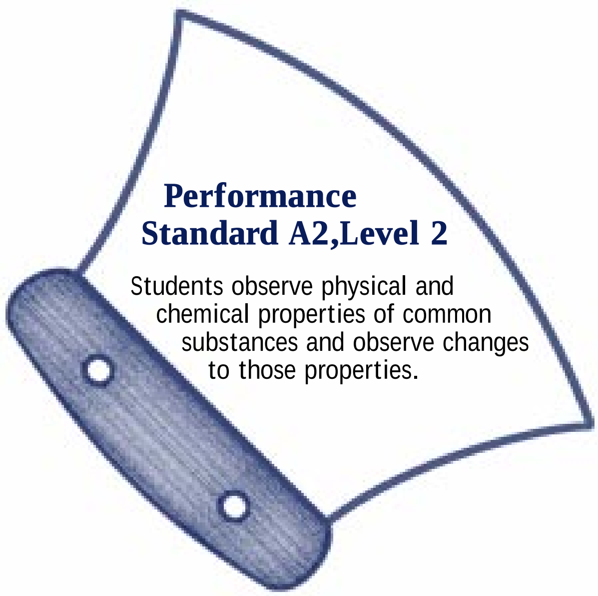
A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties. (Page 154).

Benchmarks

Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions. (Page 77)

When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials. (Page 77)

Mini-Unit: Water Dance



Performance Standard A2,Level 2

Students observe physical and chemical properties of common substances and observe changes to those properties.

Key Concepts and Skills

- Water exists in three states—solid, liquid, gas
- Water evaporates when heated.
- Water expands when it freezes which causes problems in Alaska
- Liquid water expands as it is heated above 4 degrees Celsius
- Water, snow and ice have many names in Iñupiaq.
- Ice is less dense than water.
- Measuring volume, temperature, density, mass.

Timeline

2–3 weeks

Abstract

Students explore states of water and changes between these states in their community. Students investigate changes as water freezes, liquefies, evaporates, and boils. Students learn many Iñupiaq names for water, ice, and snow and the significance of each name

Alaska Science Content Standard Key Element

A student who meets the content standard should understand the physical, chemical, and nuclear changes and interactions that result in observable changes in the properties of matter.

Cross-Reference

Additional Content and Performance Standards: B1, D1 and D3

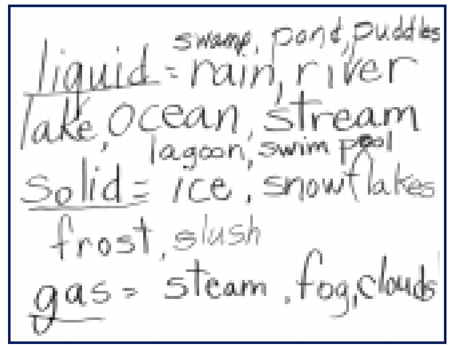
Materials

- ✔ Clipboards for note taking
- ✔ freezer to make ice cubes
- ✔ *Go Home Riv er* by Jim Magdanz
- ✔ rulers
- ✔ List of Iñupiaq names for water (see below)
- ✔ graduated cylinders
- ✔ water
- ✔ hot plates
- ✔ plastic bottles to hold water
- ✔ balance with gram masses
- ✔ pans for boiling water

Activities

1

Read the book *Go Home Riv er* by Jim Magdanz; ask the students what they know about the states of water, how and where it exists around the community. List.



Embedded Assessment

Check list for previous understanding of concepts.


I'm a WATER WATCHER.
This is what I see:

- water droplets on plants
- water droplets on windows
- wet clothes on a clothesline
- a puddle
- a muddy spot that was once a puddle
- a place that shows soil erosion
- clouds
- a storm drain
- water running in the gutter
- a water meter
- a water tower
- a drinking fountain
- a sprinkler
- a water faucet
- a stream
- a lake
- a river
- a reservoir

2

Take students for a "water walk" around the community; list a variety of usual and unusual forms in which water exists in their environment and changes in the states of water that are observed at different seasons; record in journal; share with the class.

3

Students conduct an interview of Elders or adults in the community or their family. Before they go, you may want to review the relevant forms of water in all three states, such as snow, sleet, permafrost, fog, clouds, etc.

Help students generate questions to ask, such as the following: How does water's change of state during break-up or freeze-up affect your life/job? What problems does the change of state of water cause in your community? What solutions have people found to solve these problems?

When students return from their interview, they share the information and stories they collected. Discuss Brainstorm a list of properties of each of the states of water (local examples as well as global examples). Introduce different Iñupiaq names for water and snow. Discuss how each Iñupiaq form is different and why a new word for each type of water and snow is helpful.

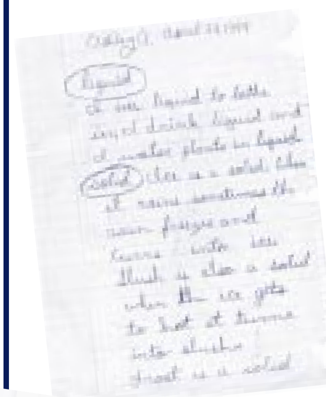
avun	powder snow	*qannatuq*	snow falling down
sigu	ice	*qilakluk*	cloud
aniu	snow on ground	*qaniq*	snowflake
kuuk	river	*iziq*	steam

4

Fill a clear plastic bottle or pop can with water. Replace cap. Ask students to predict what will happen when the bottle is frozen. Record predictions and explanations in journals using words and pictures. Make qualitative and quantitative observation of the bottle/cans of water. Record observations in journals. Put bottles/cans outside (if cold enough) or in freezer. After it is frozen record both qualitative and quantitative observations.

Expanded Sample Assessment Idea

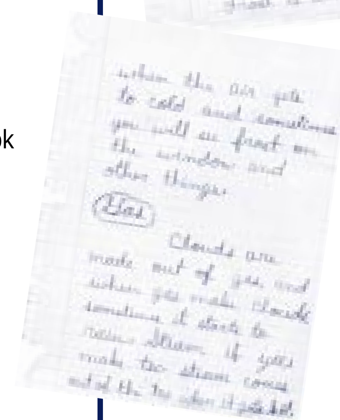
Students develop a strategy to sink an ice cube.



Procedure

Students will:

1. Predict if they can sink an ice cube.
2. Work in teams to develop a strategy to make the ice sink.
3. Demonstrate their ice-sinking apparatus; share strategies and observations with the class.



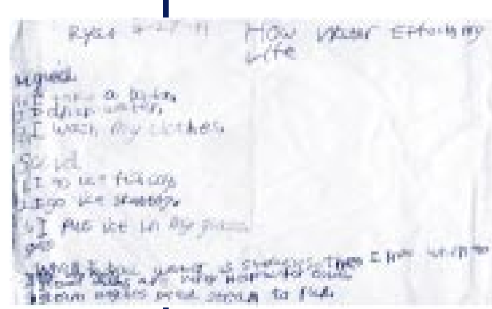
Reflection and Revision

Why is ice so hard to sink? Discuss the properties of ice and water (what they look like, feel like, smell like, taste like and how they behave in relation to sinking and floating.) How are these two forms of water alike and how are they different? Discuss density.

Levels of Performance

Stage 4 — Student work is complete, correct, shows evidence of logical reasoning and transfer and extension of knowledge related to the physical properties of the three states of water. Explanation of water's change of state includes correct terminology, physical properties of each state of water, a description of where each phase occurs in nature, and an example of how each change in the state of water affects the local community. The student describes a detailed strategy to sink an ice cube or explains why it isn't possible.

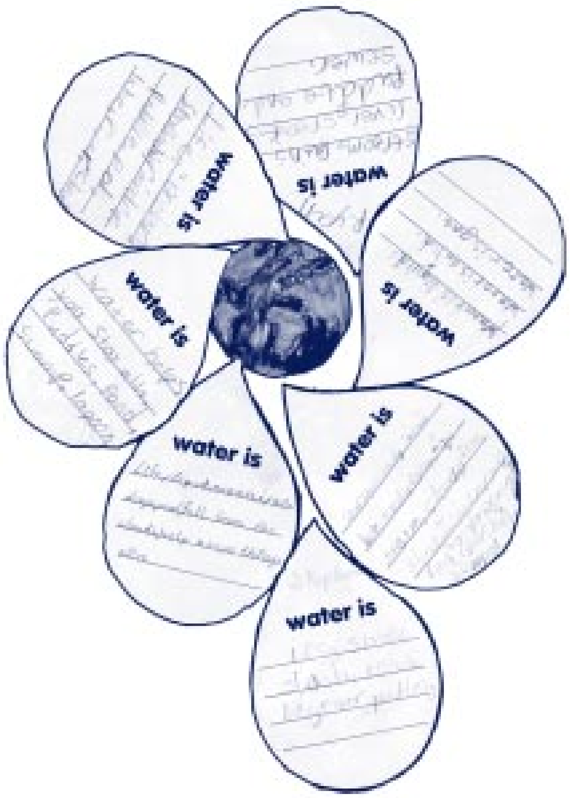
Stage 3 — Student work shows evidence of logical reasoning and transfer of knowledge related to the physical properties of the three states of water, but may contain minor errors or omissions. Student explanation of water's change of state includes correct terminology, physical properties of some of the states of water, some descriptions of where water occurs in nature and at least one example of how a change in the state of water affects the local community. The student describes a strategy to sink an ice cube.



Stage 2 — Student work contains omissions or errors of science fact and reasoning. Student explanation of water's change of state may identify an example of where water occurs in nature, describes an example of how water is used within the local community, uses some appropriate terminology, and may describe some physical properties of water in one of its three states. A strategy to sink an ice cube, if included, may be incomplete or lack detail.

Stage 1 Student explanation of the change of state of water is largely incomplete, incorrect, and shows little evidence of understanding the role of water in the local community.

Standards Cross-References



National Science Education Standards

Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. These properties can be measured using tools, such as rulers, balances, and thermometers. (Pg. 127)

Materials can exist in different states – solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling. (Pg. 127)

A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties. (Pg. 154)

Benchmarks

Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions. (Pg. 77)

When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials. (Pg. 77)

Alaska Science Key Element A3

A student who meets the content standard should understand models describing the composition, age, and size of our universe, galaxy, and solar system and understand that the universe is constantly moving and changing (Universe).

Performance Standard Level 2, Ages 8–10

Students make observations of the daytime and nighttime sky and create a 3-dimensional model to explain the movement of the Earth and moon in our solar system.

Sample Assessment Ideas

- Students use models to demonstrate the motion and position of the sun during Alaska's summer and winter days; explain the cause of these dramatic seasonal changes
- Students describe the daily, monthly, and yearly motion of the moon.

Standards Cross-References

National Science Education Standards

An object's motion can be described by tracing and measuring its position over time. (Page 127)

The Earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system. (Page 160)

Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses. (Page 160)

Benchmarks

The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. (Page 68)

Like all planets and stars, the Earth is approximately spherical in shape. The rotation of the Earth on its axis every 24 hours produces the night-and-day cycle. To people on Earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the Earth once a day. (Page 63)

Planets change their positions against the background of stars. (Page 63)

The Earth is one of several planets that orbit the sun, and the moon orbits around the Earth. (Page 63)

Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. (Page 63)

Alaska Science Key Element A4

A student who meets the content standard should understand observable natural events such as tides, weather, seasons, and moon phases in terms of the structure and motion of the Earth (Earth).

Performance Standard Level 2, Ages 8–10

Students observe natural events related to weather, seasons, and phases of the moon, and identify patterns in their observations.

Sample Assessment Ideas

- Students observe, record, and describe the motion of the moon during one day or night.
- Students observe, record, and describe the phase changes of the moon during one month.
- Students discuss past ice-flow break-up dates; identify possible weather patterns regarding break-up.

Expanded Sample Assessment Idea

- Students create a song or poem to describe patterns in the weather

Procedure

Students will:

1. Interview Elders to learn Native weather-related terminology; listen to native songs and song patterns; identify weather patterns and Native ways to predict them.
2. Collect daily weather measurements of temperature, wind speed and direction, and precipitation for two months.
3. Observe cloud formations and corresponding satellite weather pictures
4. Analyze the data for patterns.
5. Write a song or poem that describes patterns in the weather over time Use repeating parts of the song or poem to emphasize specific weather information.
6. Share song or poem with the class

Reflection and Revision

What specific knowledge did you hope to impart through your song or poem? What part of the song or poem tells about the patterns in the weather? How do the repeating parts of your song or poem emphasize specific weather information? Why is this information important to emphasize?

Level of Performance

Stage 4 The student song or poem accurately describes changing weather patterns using scientific knowledge, data collected during daily weather measurements, and indigenous knowledge or stories. The song or poem and the explanation show detailed evidence of transfer and extension of weather-related knowledge

Stage 3 The student song or poem accurately describes changing weather patterns using several examples of scientific knowledge, data collected during daily weather measurements, or indigenous knowledge and stories. The song or poem and the explanation show evidence of transfer and extension of weather-related knowledge, but may contain minor errors or omissions.

Stage 2 The student song or poem may contain evidence of skilled word-play but may be incomplete, incorrect, or lack scientific weather detail. Student work shows limited evidence of weather-related knowledge, transfer or extension of this knowledge, and may contain errors of science fact and reasoning.

Stage 1 — The student song or poem and explanation are largely incomplete, incorrect, and show little or no evidence of weather-related knowledge, transfer, or extension of this knowledge

Standards Cross-References

National Science Education Standards

Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation. (Page 134)

Most objects in the sky are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses. (Page 160)

Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the Earth's surface and explains the phenomena of the tides. (Page 161)

The sun is the major source of energy for phenomena on the Earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the Earth's rotation on its axis and the length of the day. (Page 161)

Benchmarks

Things on or near the Earth are pulled toward it by the Earth's gravity. (Page 68)

Like all planets and stars, the Earth is approximately spherical in shape. The rotation of the Earth on its axis every 24 hours produces the night-and-day cycle. To people on Earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the Earth once a day. (Page 68)

When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water. (Page 68)

Air is a substance that surrounds us, takes up space, and whose movement we feel as wind. (Page 68)

Level 2

Alaska Science Key Element A5

A student who meets the content standard should understand the strength and effects of the forces of nature, including gravity and electromagnetic radiation (Forces of Nature).

Performance Standard Level 2, Ages 8–10

Students observe the force and energy manifestations of nature, such as gravity, magnetism, light and electricity and their interactions with a variety of materials.

Sample Assessment Ideas

- Students describe and explain how the weight of an object will be different on the moon and on the Earth.
- Students describe and explain static electricity—create charges by rubbing rabbit fur on different materials; compare the charges created and rank each material according to amount of charge produced.
- Students measure how the push / pull of poles of magnets varies with the distance apart; chart or graph the results
- Students draw ray diagrams to explain how an image is formed in a mirror; predict where the image will appear.

Standards Cross-References

National Science Education Standards

Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the Earth's surface and explains the phenomena of the tides. (Page 161)

Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye. (Page 155)

Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced. (Page 155)

Benchmarks

The Earth's gravity pulls any object toward it without touching it. (Page 94)

Without touching them, a magnet pulls on all things made of iron and either pushes or pulls on other magnets. (Page 94)

Without touching them, material that has been electrically charged pulls on all other materials and may either push or pull other charged materials. (Page 94)

Alaska Science Key Element A6

A student who meets the content standard should understand that forces of nature cause different types of motion, and describe the relationship between these forces and motion (Motion).

Performance Standard Level 2, Ages 8–10

Students predict how an object's speed, motion and direction change when outside force is applied.

Sample Assessment Ideas

- Students explore how a change in ramp height or mass of car affects the speed, direction, and distance traveled by cars on ramps.
- Students observe the motion in a Newton's' cradle demonstration; explain forces and motion involved.

Expanded Sample Assessment Idea

- Students build a miniature sled; measure the average speed at which it moves when different forces are applied.

Materials

Meter stick, wooden block with screw at end, length of light cord or fishing line, holder for weights (cup with hood or strings), weights (washers or small fishing weights), stopwatch

Procedure

Students will:

1. Lay out a measured track on the table by marking off 10 cm intervals. (NOTE: The speed of the sled will change as it moves, so the accuracy of the measuring marks will be very important.)
2. Attach the cord or line to the block (sled) and to the weight (mass) holder; position the sled so the holder hangs over the edge of the table and the sled is stationed at the beginning of the track.
3. Add weights to the holder until the sled just starts to move.
4. Measure the time it takes for the sled to travels the length of the track; record all measurements; calculate the speed by dividing the distance traveled by the time it took to travel that distance.
5. Repeat the experiment (steps 3–4) two or three times.
6. Double the number of weights in the holder and repeat steps 3–5.
7. Organize and tabulate data; make appropriate graphs.
8. Compare class data from different sled sizes, different materials, different masses on sleds, and so on.

Reflection and Revision

Are the results the same when you compare trials 1, 2 and 3? What causes the results to vary? How could the procedure be improved to reduce the amount of variability? How will the results change if the sled moves along a different track surface? What would happen if you had a pulley for the line to go over at the table's edge? Why? Is there a pattern with the size of sled? Mass of sled? Material for the track?

Levels of Performance

Stage 4 — Student work is complete, well-organized, and shows detailed evidence of the transfer and extension of knowledge that relates forces to an object's speed, motion, and change in direction. All measurements, calculations, and graphs are accurate and clearly labeled. Students' experimental analysis includes a detailed discussion of factors that affect reliability (track surface, friction, maintaining straight-line motion, etc.) and student incorporates this information to suggest appropriate experimental design changes that will reduce variability.

Stage 3 — Student work is mostly complete, organized, and shows some evidence of the transfer or extension of knowledge that relates forces to an object's speed, motion, or change in direction. Most measurements, calculations, and graphs are accurate and labeled, although they may contain minor errors or omissions. Student's experimental analysis includes a discussion of at least two factors that affect reliability (track surface, friction, maintaining straight-line motion, etc.) and student uses some of this information to suggest an experimental design change to reduce variability.

Stage 2 — Student work may be incomplete or poorly organized and shows little evidence of knowledge relating to forces, speed, or motion of an object. Measurements, calculations, and graphs are included but are incomplete, missing labels, or incorrect. Student's experimental analysis, if included, may contain misconceptions or errors of reasoning.

Stage 1 — Student work is mostly incomplete, incorrect, or contains evidence of major misconceptions relating to forces, speed, or motion of an object.

Standards Cross-References

National Science Education Standards

The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph. (Page 154)

An object that is not being subjected to a force will continue to move at a constant speed and in a straight line. (Page 154)

Benchmarks

Changes in speed or direction of motion are caused by forces. The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have. (Page 89)

How fast things move differs greatly. Some things are so slow that their journey takes a long time; others move too fast for people to even see them. (Page 89)

Alaska Science Key Element A7

A student who meets the content standard should understand how the Earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things (Processes that Shape the Earth).

Performance Standard Level 2, Ages 8–10

Students observe and describe changes in the local environment caused by weather, waves, wind, water, ice, and living organisms.

Sample Assessment Ideas

- Students take a field trip to observe and describe local geologic features (rivers, mountains, valleys, rock outcroppings, erosion, changes to tundra and permafrost, and so on); map the location of rocks they observe on the trip; discuss where these rocks may have originated, and what events might have caused rocks' movement to this site
- Students identify local evidence of erosion and deposition of materials; explain the cause of erosion and deposition including forces of the river or sea.

Expanded Sample Assessment Idea

- Students build a stream table to examine erosion.

Procedure

Students will:

1. Work with a team of 3–4 students to design and build a stream table that will demonstrate the effect of moving water on the Earth's surface. (Use local soil, gravel, and rocks in a wooden box or plastic container.)
2. Draw a diagram that shows the position of the rocks, gravel, and soil in the stream table
3. Tilt the table; pour a continuous supply of water onto the stream table.
4. Draw another diagram that shows the changes created by water.
5. Change the stream bed; make a new diagram that shows the change in the variable; add water; draw a diagram that shows the changes observed.

Reflection and Revision

What would happen if the quantity of water in the stream was increased? How can a stream table model be used to make predictions that would help the local community?

Level of Performance

Stage 4 — Student work is complete, shows evidence of logical reasoning, and knowledge of changes in stream beds caused by moving water. Before and after diagrams are clearly labeled and contain multiple details of the stream table demonstration.

Stage 3 — Student work may contain minor errors or omissions but shows evidence of logical reasoning and knowledge of changes in the stream beds caused by moving water. Before and after diagrams are labeled and contain some details related to the stream table demonstration.

Stage 2 — Student work is incomplete, incorrect, lacks detail, may contain errors of science fact and reasoning, and shows limited evidence of knowledge of changes in the stream beds caused by moving water. Diagrams may show skilled artwork but limited information related to the stream table demonstration.

Stage 1 Student work is mostly incomplete, incorrect, and contains errors of science fact and reasoning, and shows little or no evidence of knowledge of how moving water changes the steam beds. Diagrams may show skilled artwork, but do not describe the stream table demonstration.

Standards Cross-References

National Science Education Standards

The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. (Page 134)

Water, which covers the majority of the Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the Earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. (Page 160)

Living organisms have played many roles in the Earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks. (Page 160)

Benchmarks

Waves, wind, water and ice shape and reshape the Earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers. (Page 72)

Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains-and also contains many living organisms. (Page 72)

Alaska Science Key Element A8a

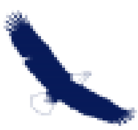
A student who meets the content standard should understand the scientific principles and models that describe the nature of physical, chemical, and nuclear reactions (Energy Transformations).

Performance Standard Level 2, Ages 8–10

Students observe and describe physical and chemical changes to a system.

Sample Assessment Ideas

- Students examine and describe properties of non-Newtonian fluids (such as a mixture of water and corn starch a.k.a. “Oobleck”); compare with the properties of the starting substances.
- Students saw a wooden board into pieces; compare properties; burn half the pieces; compare the resulting ash with the unburned pieces; account for gain or loss of volume and/or mass.



Expanded Sample Assessment Idea

- Students investigate and report on several mixture systems to determine characteristics of physical and chemical change.

Materials

- ✔ test tubes or well trays
- ✔ chemicals in both solid and solution form, such as sodium chloride (salt), sodium bicarbonate (baking soda), acetic acid (white vinegar), silver nitrate

Suggestions for mix systems:

- salt + water, stir
- allow (1) to evaporate
- baking soda + water, stir
- allow (2) to evaporate
- vinegar + solution (1)
- vinegar + solution (3)
- silver nitrate + solution (1)
- silver nitrate + solution (3)

Procedure

Students will:

1. Observe and record appearance of substances before and after mixing,
2. Observe and record behavior of substances during mixing.

Reflection and Revision

What properties do the substances have in common? What properties are different? What is evidence of physical change? What is evidence of chemical change? Which mixing operations fall into which category and why?

Levels of Performance

Stage 4 — Student response shows clear understanding of evidence regarding chemical reactions vs. physical changes taking place in matter rearrangements. Observations are thorough and interpreted with considerable detail and logical reasoning.

Stage 3 — Student response shows understanding of evidence regarding chemical reactions vs. physical changes taking place in matter rearrangements. Observations are thorough and interpreted with some evidence of logical reasoning. Minor errors may be present.

Stage 2 — Student response shows limited understanding of the difference between physical and chemical changes. Observations are minimal and interpreted with limited evidence of logical reasoning.

Stage 1	Student response shows little understanding of physical or chemical change. Observations are minimal or totally incorrect, and interpretations show lack of scientific reasoning.

Standards Cross-Referenced

National Science Education Standards

Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group. (Page 154)

Benchmarks

Heating and cooling cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions. (Page 77)

When a new material is made by combining two or more materials, it has properties that are different from the original materials. For that reason, a lot of different materials can be made from a small number of basic kinds of materials. (Page 77)

Alaska Science Key Element A8b

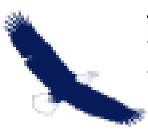
A student who meets the content standard should understand the scientific principles and models that state whenever energy is reduced in one place, it is increased somewhere else by the same amount (Energy Transformations).

Performance Standard Level 2, Ages 8–10

Students observe and describe heat flow from one object to another

Sample Assessment Ideas

- Students examine traditional ways of heating water—putting hot rocks into a birch basket—and determine which heats water the fastest—many small rocks or a few large rocks.
- Students place a metal container with cold water in another larger insulated container containing hot water; measure temperature changes in both containers; explain the transfer of thermal energy from hot to cold object.
- Students design mittens to wear outside when they go to recess; discuss the qualities of a "good" mitten; choose the material to use to make the mittens; make a list of words that describe the material for the mittens; describe how their mitten design is better than the mittens they have right now; make an advertisement that they could use to "sell" their mittens.



Expanded Sample Assessment Idea

- Students design ways to keep an ice cube from melting.

Procedure

Students will:

1. Create a container to hold an ice cube. (Have a variety of materials available for the students to choose from, including, paper, cotton, cups, sticks, fur, feathers, foil, styrofoam, tape, glue, and other materials.)
2. Put an ice cube inside the container; place it in the designated spot.
3. Check the ice cubes as necessary; record observations in a journal.
4. Compare results with other students in class.
5. Discuss the properties of insulators and conductors.

Reflection and Revision

Which containers worked best as insulators? Describe one change you would make to your container to make it work better. How will this change make the container better?

Levels of Performance

Stage 4 — Student work is complete and shows detailed evidence of the transfer and extension of knowledge related to heat flow. Journal contains evidence of the transfer or extension of knowledge related to heat flow. Journal contains observations of the melting ice cube. Student designs and constructs a container that slows the progress of melting, and describes changes that would improve the container.

Stage 3 — Student work is mostly complete and shows detailed observations of the melting ice cube. Student designs and constructs a box that prevents the ice cube from melting, and describes and explains in detail changes that would improve the container.

Stage 2 — Student work may be incomplete and shows limited evidence of knowledge related to heat flow. Journal contains incomplete observations of the melting ice cube. Student work may show evidence of skilled craftsmanship but the box design does little to slow the progress of melting. Student may describe changes to the container that would not alter its insulating capabilities.

Stage 1 Student work is mostly incomplete, inappropriate, shows little evidence of craftsmanship or knowledge related to insulating abilities of materials.

Standards Cross-References

National Science Education Standards

Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. (Page 155)

Benchmarks

When warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are at the same temperature. A warmer object can warm a cooler one by contact or at a distance. (Page 84)

Alaska Science Key Element A8c

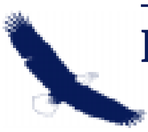
A student who meets the content standard should understand the scientific principles and models that state that whenever there is a transformation of energy, some energy is spent in ways that make it unavailable for use (Energy Transformations).

Performance Standard Level 2, Ages 8–10

Students determine heat conductivity of various materials.

Sample Assessment Ideas

- Students explain why different types of clothing are worn in different weather conditions.
- Students list several heat conductors and heat insulators found in their home; explain the different job that each does.



Expanded Sample Assessment Idea

- Students measure the conductivity of different insulation materials as a function of thickness; predict which could be used to build a home for winter or summer use.

Materials

- ✔ heat lamp (or could be done outdoors in the sunlight in summer)
- ✔ thermometer
- ✔ blocks of various materials of differing thickness such as wood, brick or concrete, fiberglass (covered and sealed), wallboard, ice blocks (where available) and so on.)

Procedure

Students will:

1. Discuss the best way to set up the lamp over the material with the thermometer underneath so that the different measurements can be compared.
2. Discuss what is the best measure to judge insulation—the temperature after a certain time, or the maximum temperature that is reached?
3. Set up each material according to the class design.
4. Measure the temperatures as a function of time; record and graph the data.
5. Compare results with other students in class; graph class data to show different thickness and different materials.

Reflection and Revision

How could measurements be improved to get more reproducible results? Identify and explain insulation in your home/community that works this way. What happens to the heat in each case? Which is the best material for building? Why? Does it depend on the weather? Is there a difference in insulating against cold rather than heat (imagine if you lived in the desert)? Why or why not?

Levels of Performance

Stage 4 Student work is complete and shows clear evidence of ability to conduct a reproducible experiment to measure heat conduction. Data and observations are recorded in detail. Student describes an appropriate method to improve the reproducibility of the measurements. Student accurately identifies and explains in detail insulators and conductors used in their home. Building applications for both hot and cold climates are discussed in detail and shows extensive evidence of the transfer of knowledge.

Stage 3 Student work is complete and shows evidence of ability to conduct an experiment to measure heat conduction. Data and observations are recorded. Student describes a method that affects the measurements, although it may not improve the reproducibility. Student accurately identifies and explains an insulator and a conductor used in their home Building applications for both hot and cold climates are discussed and shows evidence of the transfer of knowledge.

Stage 2 Student work may be incomplete and shows limited evidence of ability to conduct an experiment to measure heat conduction. Data and observations are recorded but errors are made. Student may not include suggestion for improving the measurements Student identifies an insulator or conductor used in their home but may not include an explanation of its use. Building applications, if present, lack detail and show limited transfer of knowledge.

Stage 1 Student work is mostly incomplete and shows misconceptions regarding experimental design and heat conduction. Data and observations are incomplete or incorrectly recorded. Student identifies an insulator or conductor used in their home. Building applications, if present, are incorrect and show evidence of misconceptions

Standards Cross-References

National Science Education Standards

Heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another. Heat can move from one object to another by conduction. (Page 127)

Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature. (Page 155)

Benchmarks

Things that give off light also give off heat. Heat is produced by mechanical and electrical machines, and any time one thing rubs against something else. (Page 84)

When warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are at the same temperature. A warmer object can warm a cooler one by contact or at a distance. (Page 84)

Some materials conduct heat much better than others. Poor conductors can reduce heat loss. (Page 84)

Level 2

Alaska Science Key Element A9

A student who meets the content standard should understand the transfers and transformations of matter and energy that link living things and their physical environment from molecules to ecosystems (Flow of Matter and Energy).

Performance Standard Level 2, Ages 8–10

Students describe the cycling of matter and transfer of energy in the local ecosystem.

Sample Assessment Ideas

- Students diagram a food chain starting with a local animal (such as salmon or small mammal) and trace the matter and energy back to plants and the sun.
- Students diagram the cycle of growth, decay, and renewal that begins in a compost pile and continues as the gardener uses the compost on a garden.

Standards Cross-References

National Science Education Standards

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers–they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. (Page 157)

For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. (Page 158)

Benchmarks

Almost all kinds of animals' food can be traced back to plants. (Page 119)

Some source of "energy" is needed for all organisms to stay alive and grow. (Page 119)

Over the whole Earth, organisms are growing, dying, and decaying, and new organisms are being produced by the old ones. (Page 119)

Alaska Science Key Element A10

A student who meets the content standard should understand that living things are made up mostly of cells and that all life processes occur in cells (Cells).

Performance Standard Level 2, Ages 8–10

Students recognize the basic requirements for all living things: food, water, waste disposal and reproduction.

Standards Cross-References

National Science Education Standards

All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular. (Page 156)

Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs. (Page 156)

Benchmarks

Some living things consist of a single cell. Like familiar organisms, they need food, water, and air; a way to dispose of waste; and an environment they can live in. (Page 111)

Microscopes make it possible to see that living things are made mostly of cells. Some organisms are made of a collection of similar cells that benefit from cooperating. Some organisms' cells vary greatly in appearance and perform very different roles in the organism. (Page 111)

Alaska Science
Key Element A11

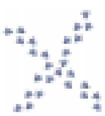
A student who meets the content standard should understand that similar features are passed on by genes through reproduction (Heredity).

Performance Standard Level 2, Ages 8–10

Students identify characteristics of plants and animals that are inherited as well as characteristics of plants and animals that are influenced by the environment.

Sample Assessment Ideas

- Students examine the phenomenon of "snowballing" on dogs' feet; identify the characteristics of the dog and factors of the environment that affect this tendency.
- Students grow FAST® plants for two generations; keep a journal with details about inherited characteristic (leaf shape, flower color, number of seeds and so on.)



Standards Cross-References

National Science Education Standards

Plants and animals closely resemble their parents. (Page 129)

Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation. (Page 129)

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment. (Page 157)

Benchmarks

Some likenesses between children and parents, such as eye color in human beings, or fruit or flower color in plants, are inherited. Other likenesses, such as people's table manners or carpentry skills, are learned. (Page 107)

For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. (Page 107)

Level 2

Alaska Science Key Element A12

A student who meets the content standard should distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life and understand the theories that describe the importance of diversity for species and ecosystems (Diversity).

Performance Standard Level 2, Ages 8–10

Students categorize groups of plants and animals according to external features and explain how these features help organisms survive in different environments

Sample Assessment Ideas

- Students match a given external feature (for example, feet, ears, teeth, leaves, roots) with their use; describe how this external feature helps the organism to survive in its environment.
- Students design an animal that can survive in a particular environment.

Standards Cross-References

National Science Education Standards

Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking. (Page 129)

Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms. (Page 129)

Benchmarks

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group. (Page 103)

Features used for grouping depend on the purpose of the grouping. (Page 103)

Alaska Science Key Element A13

A student who meets the content standard should understand the theory of natural selection as an explanation for evidence of changes in life forms over time (Evolution and Natural Selection).

Performance Standard Level 2, Ages 8–10

Students describe how living organisms have changed over time

Sample Assessment Ideas

- Students use fossil evidence to show how an animal species has changed over time (for example, horse, whale, elephant).
- Students reconstruct an animal using a card set of fossilized animal bones

Expanded Sample Assessment Idea

- Students invent a new life form and describe its relatedness to other species

Procedure

Students will:

1. Imagine they have just returned from a scientific expedition and have collected a new species of life.
2. Draw a picture or build a 3-D model of this new organism.
3. Describe the habitat in which the organism was found; describe the specialized body parts that help the organism live in its habitat.
4. Describe how the organism resembles known life forms.
5. Create a piece of fossil evidence that shows how this organism has changed over time

Reflection and Revision

What adaptation would the species need to survive in Alaska?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student drawing or model, explanation, and fossil creation show extensive evidence of knowledge of adaptations and the change of living organisms over time

Stage 3 — Student work shows evidence of logical reasoning, but may contain minor errors or omissions. Student drawing or model, explanation, and fossil creation show evidence of knowledge of adaptations and the change of living organisms over time

Stage 2 — Student work may show skilled craftsmanship but is incomplete, incorrect, or may contain errors of science fact or reasoning. Student drawing or model, explanation, and fossil creation show limited evidence of knowledge of adaptations or the change of living organisms over time.

Stage 1 — Student work is largely incomplete, incorrect, shows little evidence of understanding and may contain major misconceptions

Standards Cross-References

National Science Education Standards

An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations. (Page 129)

Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the Earth no longer exist. (Page 158)

Benchmarks

Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing. (Page 123)

Fossils can be compared to one another and to living organisms according to their similarities and differences. Some organisms that lived long ago are similar to existing organisms, but some are quite different. (Page 123)

Alaska Science
Key Element A14a

A student who meets the content standard should understand the interdependence between living things and their environments (Interdependence).

Performance Standard Level 2, Ages 8–10

Students classify familiar plants and animals based on their position in a simple food chain.

Sample Assessment Idea

- Students report on two local habitats; compare the types of plants and animals living in each habitat.
- Students report on one arctic and one non-arctic habitat; compare the plants and animals living in each habitat.

Expanded Sample Assessment Idea

- Students take a field trip to a local muskeg or pond; investigate how the needs of animals or plants are provided by the local environment.

Procedure

Students will:

1. Take a field trip to a local muskeg or pond.
2. Investigate the plant life, insects, birds, and other animals found there.
3. Investigate the physical environment including the presence of water, and type of terrain.
4. Choose one animal and one plant to focus upon.
5. Use field notes and other research to prepare a poster or written report, (include sources of food, water, shelter, air, sunlight, mates, (or pollinators), and sources of competition for resources at the site)

Reflection and Revision

What happens to the organism when a specific resource decreases? Which plants and animals are dependent on each other? What happens when the organisms die?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student correctly identifies environmental resources that provide the basic needs of the plant and animal, and predict what happens when the resources decrease.

Stage 3 — Student work shows evidence of logical reasoning, but may contain minor errors or omissions. Student correctly identifies environmental resources that provide the basic needs of the plant and animal, but may not predict what happens when the resources decrease.

Stage 2 — Student work may be incomplete, or contain errors of science fact and reasoning. Student identifies the basic needs of plants and animals, along with some environmental resources that provide those needs

Stage 1 — Student work may identify some basic needs of the plant or animal, however, it is largely incomplete, contains major misconceptions

Standards Cross-References

National Science Education Standards

All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment. (Page 157

Resources are things that we get from the living and non-living environment to meet the needs and wants of a population. (Page 140)

Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are non-material, such as quiet places, beauty, security, and safety. (Page 140)

The supply of many resources is limited. If used, resources can be extended through recycling and decreased use. (Page 140)

Benchmarks

For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all. (Page 116)

Insects and various other organisms depend on dead plant material for food. (Page 116)

Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds (Page 116)

Alaska Science
Key Element A14b

A student who meets the content standard should understand that the living environment consists of individuals, populations, and communities (Interdependence).

Performance Standard Level 2, Ages 8–10

Students identify groups of plants and animals that live within characteristic biomes.

Sample Assessment Ideas

- Students collect pictures of plants and animals, and group them according to the biome in which they live.
- Students identify four species of animals that live within 10 miles of their home.

Expanded Sample Assessment Idea

- Students prepare a class report that discusses the life-cycle and habits of a solitary living animal or an animal that lives in a group, with special attention to the environment in which the animal lives.

Procedure

Students will:

1. Choose an animal to study.
2. Discuss with Elders the behavior and life cycle of the animal and how this affects the animals' survival (if the animal is endemic to Arctic region.)
3. Conduct library research and produce a report.

Reflection and Revision

What living-arrangement changes occur during the animals' life cycle? How old is the animal when it separates from its mother? What would change if the solitary animal lived in a group or the group animal lived alone? What advantage is there to living in a group? What advantage is there to living alone? What dangers are faced by the animals that live in a group? What dangers are faced by the animal that lives alone?

Level of Performance

Stage 4 Student work is complete, shows evidence of logical reasoning and knowledge related to animal life cycles. The report is detailed and includes information related to: the animal's social behavior and behavioral changes which occur throughout the animal's life cycle; how the animal's behaviors affects other individuals of both genders and the community as a whole; and advantages and dangers of both solitary living and group-living.

Stage 3 Student work shows evidence of knowledge related to animal life cycles as well as logical reasoning but may contain minor errors or omissions. The report includes information related to: the animal's social behavior, and at least one behavioral change that occurs during the animal's life cycle; how the animal's behaviors affect other individuals of both genders and the community as a whole; advantages and dangers of solitary living or group living.

Stage 2 Student work is incomplete, shows limited evidence of knowledge related to animal life cycles and may contain errors of science fact and reasoning. The report may include information related to: the animal's social behavior; how the animal's behaviors affect other individuals or the community as a whole; or advantages and dangers of solitary living vs group living.

Stage 1 Student work is largely incomplete, shows little evidence of knowledge related to animal life cycles, and may contain major misconceptions.

Standards Cross-References

National Science Education Standards

A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. (Page 157)

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. (Page 157)

Benchmarks

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group. (Page 103)

Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds (Page 116)

Alaska Science Key Element A14c

A student who meets the content standard should understand that a small change in a portion of an environment may affect the entire environment (Interdependence).

Performance Standard Level 2, Ages 8–10

Students describe migration, hibernation, and other seasonal patterns of local animals.

Sample Assessment Ideas

- Students study caribou migration and prepare a written report.
- Students research and debate the impact of building a bicycle trail or nature trail through a local wildlife refuge.

Expanded Sample Assessment Idea

- Students study bird migration and prepare an oral or written report of their findings

Procedure

Students will:

1. Choose a local migratory bird and study its migration habits.
2. Make personal observation and conduct interviews with Elders and other local people to learn when the birds leave and when they come back to the area.
3. Use additional resources including reference materials or Internet to discover why the birds migrate, and the environments of both habitats.
4. Prepare an oral or written report of their findings to present to the class

Reflection and Revision

Consider the food the birds eat at both ends of the migration.

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student prepares a detailed report that includes a description of when and where the birds migrate, underlying factors responsible for the migration, and the time of migration.

Stage 3 — Student work shows evidence of logical reasoning but may contain minor errors or omissions. Student prepares a report that includes: a description of when and where the birds migrate, factors that influence migration, and may include the time of migration.

Stage 2 — Student prepares a report about a migratory bird, but it may be incomplete, or contain errors of science fact and reasoning.

Stage 1 — Student report is largely incomplete, incorrect, shows little evidence of understanding, and may contain major misconceptions

Standards Cross-References

National Science Education Standards

All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial. (Page 129)

Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods of time. (Page 140)

An organism's behavior evolves through adaptation to its environment. How a species lives, obtains food, reproduces, and responds to danger are based in the species' evolutionary history. (Page 157)

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. (Page 158)

Benchmarks

Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. (Page 116)

Alaska Science Key Element A15

A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

Performance Standard Level 2, Ages 8–10

Students identify the limiting factors for the survival of local plants and animals

Sample Assessment Ideas

- Students observe and discuss local animals, including how limiting factors effect these animals.
- Students take a field trip to a wetland area and an area that has been cleared to support urban growth. List and compare plants and animals in each setting.
- Students interview community members to learn traditional practices of fish and wildlife co-management based on generational knowledge; compare with federal strategies based on annual scientific studies.

Expanded Sample Assessment Idea

- Students list local resources, determine if they are declining or increasing, and research possible causes for the changes (cold temperature, lack of precipitation, pollution, human impact, and so on.)

Procedure

Students will:

1. Generate a list of local resources.
2. Select small groups to research different resources from the list, and possible limiting factors and their impact.
3. Use research to prepare and give a presentation on their resource using visual aids (posters, charts, graphs, slides, photographs, pictures, etc.)

Reflection and Revision

Determine a method to align management of several resources.

Level of Performance

Stage 4 — Student work is complete, contains extensive evidence of knowledge regarding resource and limiting factors and shows evidence of logical reasoning. Research for presentation includes multiple sources. Presentation is well organized, interesting, informative, and includes several visual aids.

Stage 3 — Student work shows evidence of logical reasoning but may contain minor errors or omissions. Student work contains evidence of knowledge regarding resources and limiting factors. Research for a presentation includes more than one source. Student work is organized, interesting, informative, and includes at least one visual aid.

Stage 2 — Student work is incomplete, may contain errors of science fact and reasoning, and shows limited understanding of resources and limiting factors. Research for presentation may be limited to one source. Presentation includes at least one visual aid though it may lack organization.

Stage 1 — Student work is largely incomplete, may be inappropriate for age level or subject matter and may contain major misconceptions regarding resources or limiting factors.

Standards Cross-References

National Science Education Standards

All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial. (Page 129)

Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply. (Page 134)

The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. (Page 134)

Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods. (Page 140)

A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. (Page 157)

Benchmarks

Waves, wind, water, and ice shape and reshape the Earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers. (Page 72)

Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains—and contains many living organisms. (Page 72)

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group. (Page 103)

For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all. (Page 116)

Insects and various other organisms depend on dead plant and animal material for food. (Page 116)

Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds. (Page 116)

Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. (Page 116)

Most microorganisms do not cause disease, and many are beneficial. (Page, 116)

Alaska Science Key Element A16

A student who meets the content standard should understand basic concepts about the Theory of Relativity, which changed the view of the universe by uniting matter and energy and by linking time with space (Relativity).

Performance Standard Level 1, Ages 5–7

There is no performance standard at this level.

Alaska Science Content Standard B

Level 2, Ages 8–10

A student should possess and understand the skills of scientific inquiry.

Level 2

Alaska Science Key Element B1

A student who meets the content standard should use the processes of science; these processes include observing, classifying, measuring, interpreting data, inferring, communicating, identifying variables, developing models and theories, hypothesizing, predicting, and experimenting.

Performance Standard Level 2, Ages 8–10

Students observe, measure, and collect data from experiments and use this information to classify, predict, and communicate about their everyday world and verify their predictions.

Sample Assessment Ideas

- Students measure the water level of a local stream, river, or ocean three times a day for one week; predict water levels for the next three days.
- Students roll marbles down an inclined plane onto surfaces of different texture to collect data on the effects of friction.

Expanded Sample Assessment Idea

- Students design their own experiment to explore the effect of sunlight on bean plants.

Procedure

Students will:

1. Plant lima beans in identical containers and soil. Place half of the containers in sun or under grow lights and half in darkness.
2. Predict what will happen and record the predictions.
3. Observe and measure plant growth daily over the course of two weeks; record observations.
4. Divide into groups of four and classify the plants in at least two different ways.
5. Share observations and classification schemes with the class. Give students the opportunity to go back and revise their classification scheme based on class discussion.

Reflections and Revisions

Revise their classification schemes based on the class discussion and make predictions for growth of other plants.

Level of Performance

Stage 4 — Student work is correct, complete, and appropriate. Student makes accurate measurements, accurate observations, evidence-based predictions, develops reasonable classification systems, and clearly communicates their ideas. Predictions and classification systems are creative and elaborate as well as accurate. Methods of communication are detailed and creative.

Stage 3 — Student work is generally correct, complete, and appropriate. Student makes accurate measurements, accurate observations, evidence-based predictions, develops reasonable classification systems and clearly communicates their ideas. There are some elaborations in observation, measurement, prediction, data collection, and communication but there may be some flaws in accuracy in those process skills.

Stage 2 Student measurements, observations, predictions, classifications, and communication are partially accurate with some inaccuracies or sloppy methods. There is little evidence of elaboration or extensions.

Stage 1 Student shows little or no ability to observe, measure, predict, classify, and communicate. There is no evidence of elaboration or extension.

Standards Cross-References

National Science Education Standards

Employ simple equipment and tools to gather data and extend the senses. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations. (Page 122)

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations. (Page 148)

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Benchmarks

Scientific investigations may take many forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological and social questions. (Page 11)

Results of scientific investigations are seldom exactly the same, but if the differences are large, it is important to try to figure out why. One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused the differences. (Page 11)

Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences. (Page 11)

Offer reasons for their findings and consider reasons suggested by others. (Page 286)

Recognize when comparisons might not be fair because some conditions are not kept the same. (Page 299)

Alaska Science Key Element B2

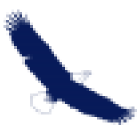
A student who meets the content standard should design and conduct scientific investigations using appropriate instruments

Performance Standard Level 2, Ages 8–10

Students conduct simple experiments to answer a specific question about the natural or designed world.

Sample Assessment Ideas

- Students experiment with different kinds of freezer paper and identify which prevents freezer burn the best.
- Students experiment with one kind of berry and different amounts of sugar to determine fermentation rates.



Expanded Sample Assessment Idea

- Students observe bean seeds and bean plants in various stages of growth and investigate the effects of changing variables (eg., water, light, fertilizer) on the growth of a bean plant.

Procedure

Students will:

1. Review the questions about plant growth listed at the beginning of the lesson and add additional questions of interest to students
2. Partner with someone who would like to ask the same question. (If a student has a question that no one else has, he or she may work alone)
3. Design their own experiment using the same kind of seeds.
4. Set up a control plant, or plants, to which no changes are made.
5. Write or select a testable question.
6. Predict what they think results will be.
7. Design an investigation to test their prediction.
8. Collect data daily. Measure and document, in words and pictures, what happens to the seed and plant. Label the plant parts at all stages
9. Repeat the experiment three times
10. Analyze data and write/illustrate results and conclusions
11. Students share with the class their experimental design, results, and conclusions, including problems they had with the investigation and how they solved them.

Reflections and Revisions

Discuss what they would do differently next time and why. Discuss how each group ensured that each test was fair (control variables, etc.).

Level of Performance

Stage 4 — Student work is complete, correct, and shows evidence of elaboration, extension, and mastery of drawing inferences based on experimental data. The investigation has a testable question, makes a prediction, lists variables, controls the variables when possible, manipulates a single variable, makes accurate measurements, records results, and makes appropriate conclusions

Stage 3 — Student work is complete but shows limited evidence of elaboration, extension and ability to draw inferences based on experimental data. The investigation includes a testable question, makes a prediction, lists some variables, controls most (but not all) variables, manipulates a single variable, makes measurements that are mostly accurate, and records results but makes inappropriate conclusions

Stage 2 — Student work may be incomplete or incorrect and shows limited evidence of understanding variables and how to manipulate them. The investigation may ask a testable question and make a prediction. However, the results are inaccurate or incomplete and the conclusions if present, does not relate to or reflect the experimental data.

Stage 1 — Student work is incomplete and incorrect. Although the investigation may consider questions about plant growth, it lacks an experimental procedure that reflects variables, controls, data collection or data manipulation.

Standards Cross-References

National Science Education Standards

Plan and conduct a simple investigation. In the earliest years, investigations are largely based on systematic observations. As students develop, they may design and conduct simple experiments to answer questions. The idea of a fair test is possible for many students to consider by fourth grade. (Page 122)

Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting). (Page 123)

Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models. (Page 148)

Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations. (Page 148)

Benchmarks

Results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which. (Page 6)

Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, or social questions. (Page 11)

Seek better reasons for believing something other than “Everybody knows that . . . ” or “I just know” and discount such reasons when given by others. (Page 299)

Mini-Unit: Bean Seeds to Plants

Performance Standard B2, Level 2

Students use appropriate instruments to conduct simple experiments to answer a specific question about the natural or designed world.

Key Concepts and Skills

Students improve experimental design techniques

Timeline

About two months

Abstract

Students will investigate the effects of changing variables such as water, light, and fertilizer on the growth of a bean plant. Students will also closely observe bean seeds and plants in various stages of growth.

Materials

- ✔ Bean seeds
- ✔ Black plastic
- ✔ Stapler
- ✔ Soil
- ✔ Measuring cups
- ✔ Dissecting equipment
- ✔ Water
- ✔ Rulers
- ✔ Tiny Seed, by Eric Carle
- ✔ Pots
- ✔ Hand lenses
- ✔ Science journals
- ✔ Fertilizer
- ✔ Zip-close bags
- ✔ Variety of fast-growing Alaskan seeds
- ✔ Grow light
- ✔ Paper towels
- ✔ Chart paper

Alaska Science Content Standard Key Element

A student who meets the content standard should design and conduct scientific investigations using appropriate instruments.

Cross-Reference

Additional Content and Performance Standards: A15, A12, A14, B1

Activities

1

Read *Tiny Seed* by Eric Carle. Show students a variety of seeds. Ask students to describe the seeds. Ask students what they know about plant growth. Ask students what questions they have about how plants grow. List questions on chart paper and display in classrooms.

2

Soak different bean seeds in water overnight. Dissect seeds and observe with hand lenses. Record observations. Ask students what new questions they have about the seeds and how they grow. List questions on another sheet of paper. Work with students to organize their questions into the following categories:

- Questions we can investigate
- Questions we can research with our own sources
- Questions we need to ask an expert

As a class, choose one question to investigate. Work as a class to write a testable question that is appropriate for the level of students, materials available, etc. Discuss variables, how to control variables and how to manipulate a single variable. Brainstorm types of observations and measurements to make. Discuss ways to record data.

3

Pass out more seeds, bags, and wet paper towels and have students place seeds in bags with wet paper towel. Hang the bags in front of a window or under a grow light. Have students observe, measure, and record data every other day as seeds sprout. They should include measurement, sketches, and observations in their journals,

Additional Activity Ideas

- Teach students the elements of a technical report and have them write up their results and conclusions.
- Have a pot-luck with different bean and vegetable dishes.
- Have students research about the University of Alaska's experimental farm activities to produce northern-adapted seeds.
- Research where the beans or Alaskan seeds they have grown come from.

Expanded Sample Assessment Idea

Students observe bean seeds and bean plants in various stages of growth and investigate the effects of changing variables (eg., water, light, fertilizer) on the growth of a bean plant.

Procedure

Students will:

1. Review the questions about plant growth listed at the beginning of the lesson and add additional questions of interest to students.
2. Partner with someone who would like to ask the same question. (If a student has a question that no one else has, he or she may work alone.)
3. Design their own experiment using the same kind of seeds.
4. Set up a control plant, or plants, to which no changes are made.
5. Write or select a testable question.
6. Predict what they think results will be.
7. Design an investigation to test their prediction.
8. Collect data daily. Measure and document, in words and pictures, what happens to the seed and plant. Label the plant parts at all stages.
9. Repeat the experiment three times.
10. Analyze data and write/illustrate results and conclusions.
11. Students share with the class their experimental design, results, and conclusions; including problems they had with the investigation, and how they solved them.

Reflections and Revisions

Discuss what they would do differently next time and why. Discuss how each group ensured that each test was fair (control variables, etc.).

Level of Performance

Stage 4 — Student work is complete, correct, and shows evidence of elaboration, extension, and mastery of drawing inferences based on experimental data. The investigation has a testable question, makes a prediction, lists variables, controls the variables when possible, manipulates a single variable, makes accurate measurements, records results, and makes appropriate conclusions.

Stage 3 — Student work is complete but shows limited evidence of elaboration, extension and ability to draw inferences based on experimental data. The investigation includes a testable question, makes a prediction, lists some variables, controls most (but not all) variables, manipulates a single variable, makes measurements that are mostly accurate, and records results but makes inappropriate conclusions.

Stage 2 — Student work may be incomplete or incorrect and shows limited evidence of understanding variables and how to manipulate them. The investigation may ask a testable question and make a prediction. However, the results are inaccurate or incomplete and the conclusion, if present, does not relate to or reflect the experimental data.

Stage 1 — Student work is incomplete and incorrect. Although the investigation may consider questions about plant growth, it lacks an experimental procedure that reflects variables, controls, data collection or data manipulation.

Standards Cross-References

National Science Education Standards

Plan and conduct a simple investigation. As students develop, they may design and conduct simple experiments to answer questions. The idea of a fair test is possible for many students to consider by fourth grade. (Page 122)

Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting). (Page 123)

Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models. (Page 148)

Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations. (Page 148)

Benchmarks

Results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which. (Page 6)

Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, or social questions. (Page 11)

Seek better reasons for believing something than "Everybody knows that . . . " or "I just know" and discount such reasons when given by others. (Page 299)

Level 2

Alaska Science Key Element B3

A student who meets the content standard should understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

Performance Standard Level 2, Ages 8–10

Students discuss multiple explanations for an observed phenomenon.

Sample Assessment Ideas

- Students observe the behavior of meal worms, earthworms, pond animals, etc. Record observations in journals. Discuss observations including patterns of behavior and possible explanations for behavior.
- Students explore a variety of moving air stations (fan, blow dryer). Teacher asks open-ended questions to elicit multiple explanations for observations

Standards Cross-References

National Science Education Standards

Ask a question about objects, organisms, and events in the environment. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations. (Page 122)

Communicate investigations and explanations. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other students. This communication might be spoken or drawn as well as written. (Page 122)

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen and to respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Benchmarks

Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences. (Page 11)

Offer reasons for their findings and consider reasons suggested by others (Page 286)

Alaska Science
Key Element B4

A student who meets the content standard should understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort, and logical reasoning are all aspects of scientific inquiry.

Performance Standard Level 2, Ages 8–10

Students use creativity and collaboration to investigate a question.

Sample Assessment Ideas

- Students work in groups in a bridge-building competition. The structure that holds the most weight is the winner.
- Students work in groups to design and carry out an investigation to examine the insulating qualities of fur.

Standards Cross-References

National Science Education Standards

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Benchmarks

Scientists do not pay much attention to claims about how something they know about works unless the claims are backed up with evidence that can be confirmed and with a logical argument. (Page 11)

Offer reasons for their findings and consider reasons suggested by others (Page 286)

Alaska Science Key Element B5

A student who meets the content standard should employ ethical standards, including unbiased data collection and factual reporting of results.

Performance Standard Level 2, Ages 8–10

Students practice factual reporting of data and identify techniques that ensure the fair collection and comparison of evidence.

Sample Assessment Ideas

- Students compete for a prize to be awarded to the student or group that can grow the tallest plant. Share data and ask if anyone was tempted to exaggerate their results. Discuss what effect this would have on the conclusions.
- Students compete in teams to build and test a model car to see which one rolls the farthest off an inclined plane. Teams will be responsible for monitoring themselves. At the end of the competition, ask if anyone was tempted to exaggerate data and whether exaggeration would be fair.

Standards Cross-References

National Science Education Standards

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations. (Page 123)

Scientists review and ask questions about the results of other scientists' work. (Page 123)

Benchmarks

Keep records of their investigations and observations and not change the records later. (Page 286)

Buttress their statements with facts found in books, articles, and databases, and identify the sources used and expect others to do the same. (Page 299)

Recognize when comparisons might not be fair because some conditions are not kept the same. (Page 299)

Alaska Science Key Element B6

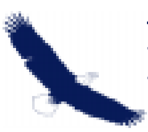
A student who meets the content standard should employ strict adherence to safety procedures in conducting scientific investigations

Performance Standard Level 2, Ages 8–10

Students examine laboratory and community safety procedures, identify how an individual affects the safety of the group, and practice safe behavior in the classroom and laboratory.

Sample Assessment Ideas

- Students review lab safety procedures; draw lab safety posters illustrating the procedures
- Students identify ten safety features in the community (guard on snow-machine clutch, kill-switch on outboard motor or snow-machine, railings on stairs, and so on).



Expanded Sample Assessment Idea

- Students review lab safety procedures and model incorrect and correct approaches for the critique of their peers.

Procedure

Students will:

1. Review lab safety procedures
2. Witness demonstrations of procedures by instructor
3. Practice proper procedures
4. Pantomime performing a task in the laboratory until stopped by the observation of their peers of a non-safe behavior.
5. Pantomime the proper approach after it is described by peers.

Reflections and Revisions

Develop a list of other areas of the school that can benefit from safety procedures

Level of Performance

Stage 4	Student work is complete, correct, and shows evidence of elaboration, extensions, and creativity. Student actively participates in a pantomime or critique that shows ability to interpret and incorporate a variety of laboratory safety procedures
Stage 3	Student work is generally complete, correct, and shows some evidence of elaboration, extensions, or creativity. Student participates in a pantomime or critique that interprets or incorporates some laboratory safety procedures
Stage 2	Student work is incomplete or shows limited ability to interpret or incorporate laboratory safety procedures
Stage 1	Student work fails to address the topic of laboratory safety. It may be entertaining, but misses major safety concerns and fails to communicate either lab safety or unsafe procedures.

Standards Cross-References

National Science Education Standards

The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions. (Page 168)

Benchmarks

One person's exercise of freedom may conflict with the freedom of others. Rules can help to resolve conflicting freedoms. (Page 172)

Alaska Science Content Standard C

Level 2, Ages 8–10

A student should understand the nature and history of science.

Alaska Science Key Element C1

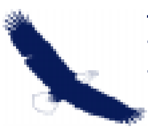
A student who meets the content standard should know how the words "fact," "observation," "concept," "principle," "law," and "theory" are generally used in the scientific community.

Performance Standard Level 2, Ages 8–10

Students will observe and record an event, then explore concepts associated with those observations and facts.

Sample Assessment Ideas

- Students attempt to roll a variety of differently shaped objects down a ramp; record their observations; generalize how the shape of the object is related to the way it rolls down the ramp.
- Students pass sugar water and silty river water through separate coffee filters; hypothesize about the differences between the filtrates and the suspensions.



Expanded Sample Assessment Idea

- Students grow plants under a variety of conditions and compare growth rates.

Procedure

Students will:

1. Divide into small groups.
2. Grow plants under a variety of conditions (amount of light, amount of water, type of soil).
3. Observe general appearance and measure the rate of growth; record observations in their science journals.
4. Make graphs comparing growth rates.
5. As a class talk about the difference between their observations and the measurements (identifying facts); discuss and generalize concepts from everyone's data.
6. Clarify the observations and facts in their findings.

Reflection and Revision

Discuss factors other than frequency of watering that will affect plant growth.

Level of Performance

Stage 4 — Student observations are correct, complete, and appropriate, and contain elaboration, extension, and evidence of higher-order thinking and relevant knowledge. There is no evidence of misconceptions. Minor errors do not necessarily lower the score.

Stage 3 — Student observations are correct, complete, and appropriate; although minor inaccuracies are present. There may be limited evidence of elaboration, extension, higher-order thinking, and relevant knowledge; or there may be significant evidence of these traits, but other flaws (e.g. inaccuracies, omissions, inappropriateness) are evident.

Stage 2 — Student observations are inaccurate, incomplete or inappropriate, although may contain some elements of proficient work. There is little, if any, evidence of elaboration, extension, higher-order thinking or relevant knowledge. There may be evidence of significant misconceptions.

Stage 1 — Student work, although it may be on topic, fails to address the question, or addresses the question in a very limited way. There is evidence of serious misconceptions.

Standards Cross-References

National Science Education Standards

Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (Page 123)

Communicate scientific procedures and explanations. With practice, students, should become competent at communicating experimental methods, and following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Benchmarks

Buttress their statements with facts found in books, articles, and databases and identify the sources used and expect others to do the same. (Page 299)

Alaska Science Key Element C2

A student who meets the content standard should understand that scientific knowledge is validated by repeated specific experiments that conclude in similar results.

Performance Standard Level 2, Ages 8–10

Students conduct simple experiments, compare their results with the work of others, and explain any differences.

Sample Assessment Ideas

- Students determine which wood smoke best repels flies while drying salmon; repeat their experiment to validate their results with the work of others.
- Students determine which brand of dog food is the favorite among a dog team; repeat the experiment with another dog team; determine generalization of findings. Any differences must be explained.

Standards Cross-References

National Science Education Standards

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations. (Page 123)

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond evidence, and suggesting alternative explanations for the same observations. (Page 148)

Benchmarks

Results of similar scientific investigations seldom turn out exactly the same. Sometimes this is because of unexpected differences in the things being investigated, sometimes because of unrealized differences in the methods used or in the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which. (Page 6)

Results of scientific investigations are seldom exactly the same, but if the differences are large, it is important to try to figure out why. One reason for following directions carefully and for keeping records of one's work is to provide information on what might have caused the differences. (Page 11)

Level 2

Alaska Science Key Element C3

A student who meets the content standard should understand that society, culture, history, and environment affect the development of scientific knowledge

Performance Standard Level 2, Ages 8–10

Students identify how various cultures throughout history have developed different units and tools for measurement.

Sample Assessment Ideas

- Students compare how various cultures throughout history have developed different methods for linear measurement.
- Students measure objects with the English and metric systems; add measurements in both systems; list pros and cons of each system.

Standards Cross-References

National Science Education Standards

Women and men of various social and ethnic backgrounds, and with diverse interests, talents, qualities, and motivations engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others (Page 170)

Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry science as a human endeavor, the nature of science, and the relationships between science and society. (Page 171)

In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture. (Page 171)

Benchmarks

Science is an adventure that people everywhere can take part in, as they have for many centuries (Page 16)

Alaska Science Key Element C4

A student who meets the content standard should understand some personal and societal beliefs accept non-scientific methods for validating knowledge

Performance Standard Level 2, Ages 8–10

Students observe a phenomenon; record a personal (non-scientific) belief about that phenomenon; compare their personal (non-scientific) belief to the scientific explanation.

Sample Assessment Ideas

- Students compile a list of beliefs about a phenomenon (tides, sunset, moonrise, day and night, etc); discuss which beliefs are personal (non-scientific) and which are scientific in nature.
- Students brainstorm reasons for plant growth and identify scientific and non-scientific statements.

Standards Cross-References

National Science Education Standards

People have always had questions about their world. Science is one way of answering questions and explaining the natural world. (Page 138)

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot. For example, new technologies often will decrease some risks and increase others (Page 169)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Seek better reasons for believing something than “Everybody knows that” or “I just know” and discount such reasons when given by others (Page 299)

Alaska Science Key Element C5

A student who meets the content standard should understand that sharing scientific discoveries is important to influencing individuals and society and in advancing scientific knowledge.

Performance Standard Level 2, Ages 8–10

Students work together to explore and share scientific discoveries about their environment.

Sample Assessment Ideas

- Students work together in teams to test different insulators (a material wrapped around a container containing water and a thermometer) under similar conditions; share results with class
- Students share information about the dates of "ice break-up" in communities across Alaska to determine weather trends

Standards Cross-References

National Science Education Standards

Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations (Page 123)

Women and men of various social and ethnic backgrounds, and with diverse interests, talents, qualities, and motivations engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others (Page 170)

Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities such as reasoning, insight, energy, skill, and creativity as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (Page 170)

Benchmarks

Clear communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world. (page 16)

Doing science involves many different kinds of work and engages men and women of all ages and backgrounds. (Page 16)

Alaska Science Key Element C6

A student who meets the content standard should understand that scientific discovery is often a combination of an accidental happening and observation by a knowledgeable person with an open mind.

Performance Standard Level 2, Ages 8–10

Students describe an historical scientific discovery that happened as a result of an accident.

Sample Assessment Ideas

- Students interview a local person who has discovered a better way to work or use a scientific principle in doing work.
- Students describe how gold or gas was discovered in Alaska.

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond evidence, and suggesting alternative explanations for the same observations. (Page 148)

Benchmarks

Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences. (Page 11)

Alaska Science Key Element C7

A student who meets the content standard should understand that major scientific breakthroughs may link large amounts of knowledge, build upon the contributions of many scientists, and cross different lines of study.

Performance Standard Level 2, Ages 8–10

Students design a timeline to show the historical development of an object or tool that they use.

Sample Assessment Ideas

- Students design concept webs that show how contributions across a variety of fields are used to produce inventions.
- Students identify commonly used objects and ask Elders what they used before the object was available.

Standards Cross-References

National Science Education Standards

Many different people in different cultures have made and continue to make contributions to science and technology. (Page 166)

Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies. (Page 169)

Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies. (Page 169)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Science is an adventure that people everywhere can take part in, as they have for many centuries. (Page 16)

Alaska Science
Key Element C8

A student who meets the content standard should understand that acceptance of a new idea depends upon supporting evidence and that new ideas that conflict with beliefs or common sense are often resisted.

Performance Standard Level 2, Ages 8–10

Students observe and describe examples of how scientific ideas that conflict with belief or common sense are resisted.

Sample Assessment Ideas

- Students do library search on historic cases of resistance to new ideas (e.g., Galileo's universe, the flat world vs. spherical world).
- Students explain how fish tenders made of heavy metal float when full of fish.

Expanded Sample Assessment Idea

- Students compare the prediction of what is in the beaker using the sense of sight and then the sense of touch.

Procedure

Students will:

1. Visually inspect two beakers that appear to contain only water.
2. Predict what the beaker contains; record their predictions.
3. Fish around in each of the beakers to discover that one beaker contains only water and one beaker contains "invisible" glass test tubes (made of glass with the same refractive index as water, available from Flinn Scientific).

Reflection and Revision

Describe how visual clues about the contents of the beakers proved incorrect and changed as counter-intuitive evidence was collected and examined.

Level of Performance

Stage 4	Student work is complete, correct, and contains evidence of elaboration, extension, higher-order thinking skills, and relevant knowledge. Students actively participate in demonstration, make accurate observations, and clearly describe their findings, conclusions, and the evidence used to "change their mind."
Stage 3	Student work is generally complete and correct although it may contain evidence of some inaccuracies or omissions. Student participates in demonstration, makes accurate observations, and describes their findings and conclusions.
Stage 2	Student work may be incomplete and inaccurate. Student is a reluctant participant in the demonstration. Observations and descriptions of findings are minimal and contain evidence of misconception and errors.
Stage 1	Student work is incomplete and inaccurate. Student does not participate in class discussion or describe the findings.

Standards Cross-References

National Science Education Standards

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work toward finding evidence that will resolve their disagreement. (Page 171)

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretation of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (Page 171)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Scientists do not pay much attention to claims about how something they know about works unless the claims are backed up with evidence that can be confirmed and with a logical argument. (Page 11)

Alaska Science Content Standard D

Level 2, Ages 8–10

A student should be able to apply scientific knowledge and skills to make reasoned decisions about the use of science and scientific innovations.

Alaska Science Key Element D1

A student who meets the content standard should apply scientific knowledge and skills to understand issues and everyday events.

Performance Standard Level 2, Ages 8–10

Students use science knowledge and reasoning to explain the science of everyday events.

Sample Assessment Ideas

- Students explain how a teeter totter works.
- Students locate, describe and explain why erosion has occurred in two places in their community.

Expanded Sample Assessment Idea

- Students compare a variety of snowshoes and use them under various conditions; identify the advantages and disadvantages of each. Explain the underlying scientific concepts.

Procedure

Students will:

1. Gather traditional snowshoes from parents and staff (1 pair of each for every group of 4).
2. Set up a relay race; run a specified distance.
3. Run one lap with traditional snowshoes, one lap with modern snowshoes. Repeat for each student.
4. After each loop, list pros and cons of the snowshoes. Decide which snowshoes are preferred by the most students; support the decision based on the relay results.

Reflection and Revision

Students consider how the different materials used in snowshoe construction affect performance.

Level of Performance

Stage 4 — Student work is complete, correct, and contains evidence of elaboration, extension, higher order thinking skills, and relevant knowledge. Student actively participates with group to perform an accurate and reliable test of the snowshoes and uses the results of the test to support the decision about which snowshoe works best.

Stage 3 — Student work is generally complete and correct but may contain evidence of some inaccuracies or omissions. Student participates with group to perform a test of the snowshoes though the test may be inaccurate or unreliable. Student decision about which snowshoe works the best is based on limited evidence from the test or on non-test related evidence.

Stage 2 — Student work may be incomplete or inaccurate. Student may be a reluctant group participant. The snowshoe test is inaccurate and unreliable. Student decision about which snowshoe works the best is not supported.

Stage 1 — Student work is incomplete and inaccurate. Student does not participate in group task or participate in a relay race or snowshoe test.

Standards Cross-References

National Science Education Standards

Use data to construct a reasonable explanation. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strengths of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others. (Page 122)

Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge. (Page 145)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Benchmarks

Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions. (Page 11)

Scientists' explanations about what happens in the world come partly from what they observe, and partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences. (Page 11)

Alaska Science Key Element D2

A student who meets the content standard should understand that scientific innovations may affect our economy, safety, environment, health, and society and that these effects may be short-term or long-term, positive or negative, and expected or unexpected.

Performance Standard Level 2, Ages 8–10

Students describe the various effects of an innovation on the safety, health and environment of the local community.

Sample Assessment Ideas

- Students examine advantages and disadvantages of traditional sinew used for thread compared with commercial threads and dental floss
- Students examine the positive and negative, long- and short-term effects of using dog teams vs. snow machines for travel.

Standards Cross-References

National Science Education Standards

People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems. (Page 138)

People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people. (Page 140)

Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world. (Page 141)

Benchmarks

Technology extends the ability of people to change the world: to cut, shape, or put together materials; to move things from one place to another; and to reach farther with their hands, voices, senses, and minds. The changes may be for survival needs, such as food, shelter, and defense, for communication and transportation, or to gain knowledge and express ideas. (Page 45)

The solution to one problem may create other problems. (Page 50)

Technology has been part of life on the Earth since the advent of the human species. Like language, ritual, commerce, and the arts, technology is an intrinsic part of human culture, and it both shapes society and is shaped by it. The technology available to people greatly influences what their lives are like. (Page 54)

Alaska Science Key Element D3

A student who meets the content standard should recommend solutions to everyday problems by applying scientific knowledge and skills.

Performance Standard Level 2, Ages 8–10

Students identify a community problem or issue and describe the information needed to develop a scientific solution.

Sample Assessment Ideas

- Students examine rocks used in steam baths and determine characteristics, location and possible geologic origin of the stones.
- Students study local landfill capacity constraints; brainstorm problems and research possible solutions.

Expanded Sample Assessment Idea

- Students identify where the residue collects in wood-burning stove pipes and discuss what can be done to prevent this fire hazard.

Procedure

Students will:

1. Help an adult "dissect" a wood stove that has been used; observe and record location of residue.
2. Observe characteristics of residue.
3. Consult with knowledgeable adult regarding best way to clean or prevent the residue build-up.
4. Test a variety of cleaning methods; record results.
5. Compare results from stoves that are cleaned differently or from stoves that have burned different woods.

Reflection and Revision

Report back to the adult who "dissected" the wood stove.

Level of Performance

Stage 4 — Student work is complete, correct, appropriate, and shows evidence of elaboration, extension, higher-order thinking skills, and relevant knowledge. Student actively participates in the dissection and cleaning of a wood-burning stove. Student accurately reports the location and characteristics of the residue, identifies the "best" methods to prevent and clean out the residue; and uses evidence to support their methods.

Stage 3 — Student work is complete and but may show limited evidence of elaboration and extension or may contain minor misconceptions or inaccuracies. Student participates in the dissection and cleaning of a wood-burning stove. Student reports the location and characteristics of the residue and identifies a method to prevent or clean out the residue.

Stage 2 — Student work may be incomplete or inappropriate and may show evidence of misconceptions and inaccuracies. Student may be a reluctant participant in the dissection and cleaning of a wood-burning stove. Student report on the residue left by the burning wood may lack detail or contain errors.

Stage 1 — Student work is incomplete, inappropriate or inaccurate. Student may not participate in the dissection or cleaning of a wood-burning stove. Student report lacks detail and contain errors.

Standards Cross-References

National Science Education Standards

Identify appropriate problems for technological design. Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product. (Page 165)

Design a solution or product. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints such as cost, time, trade-offs, and materials needed and communicate ideas with drawings and simple models. (Page 165)

Benchmarks

There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior to other ways (cost or appearance). Usually some features must be sacrificed to get others. How such trade-offs are received depends upon which features are emphasized and which are down-played. (Page 49)

The solution to one problem may create other problems. (Page 50)

Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails also must be considered. (Page 55)

Alaska Science Key Element D4

A student who meets the content standard should evaluate the scientific and social merits of solutions to everyday problems

Performance Standard Level 2, Ages 8–10

Students evaluate multiple solutions to the same problem.

Sample Assessment Ideas

- Examine a variety of ways to preserve berries; evaluate the scientific and social merits of each.
- Students consider the availability, cost, quality, and characteristics of various oils (traditional oils such as seal, bear, etc., as well as commercial oils) to determine which one is "best" for a given purpose

Standards Cross-References

National Science Education Standards

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side-effects; and technologies cost, carry risks, and provide benefits. (Page 166)

Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology. (Page 166)

Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot. (Page 166)

Benchmarks

Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. Other factors, such as cost, safety, appearance, environmental impact, and what will happen if the solution fails also must be considered. (Page 55)

Technologies often have drawbacks as well as benefits. A technology that helps some people or organisms may hurt others—either deliberately (e.g., weapons) or inadvertently (e.g., pesticides). When harm occurs or seems likely, choices have to be made or new solutions found. (Page 55)

Level 2

Alaska Science Key Element D5

A student who meets the content standard should participate in reasoned discussions of public policy related to scientific innovation and proposed technological solutions to problems.

Performance Standard Level 2, Ages 8–10

Students debate the usefulness of various science tools and technological innovations in their community.

Sample Assessment Ideas

- Students debate the usefulness of snow machines and four-wheel drives
- Students hold a community forum to discuss the usefulness of diverse tools and innovations used in the community such as an ice auger and a berry picker; a fish trap and rain gear

Standards Cross-References

National Science Education Standards

The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions. (Page 168)

Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes. (Page 168)

Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental. (Page 169)

Benchmarks

Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first. (Page 54)

Transportation, communication, nutrition, sanitation, health care, entertainment, and other technologies give large numbers of people today the goods and services that once were luxuries enjoyed only by the wealthy. These benefits are not equally available to everyone. (Page 54)

Technologies often have drawbacks as well as benefits. A technology that helps some people or organisms may hurt others—either deliberately (as weapons can) or inadvertently (as pesticides can). When harm occurs or seems likely, choices have to be made or new solutions found. (Page 55)

Because of their ability to invent tools and processes, people have an enormous effect on the lives of other living things. (Page 55)

Alaska Science Key Element D6

A student who meets the content standard should act upon reasoned decisions and evaluate the effectiveness of the action.

Performance Standard Level 2, Ages 8–10

Students work scientifically to improve a situation that exists in their local school or community.

Sample Assessment Ideas

- Students research food waste in their school; suggest and implement corrective actions; evaluate the results.
- Students examine litter patterns in their school neighborhood; come up with class actions to improve the litter problem.

Standards Cross-References

National Science Education Standards

Design a solution or product. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints such as cost, time, trade-offs, and materials needed, and communicate ideas with drawings and simple models. (Page 165)

Implement a proposed solution. Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy. (Page 165)

Evaluate completed technological designs or products. Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications. (Page 165)

Communicate the process of technological design. Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation. (Page 166)

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others. (Page 169)

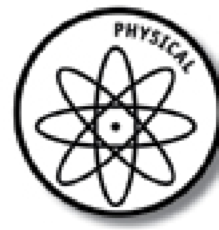
Benchmarks

Because of their ability to invent tools and processes, people have enormous effect on the lives of other living things. (Page 55)

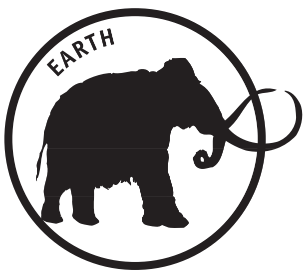
Translating Standards to Practice

A Teacher's Guide to Use and Assessment of the Alaska Science Standards

LEVEL 3, Ages 11–14

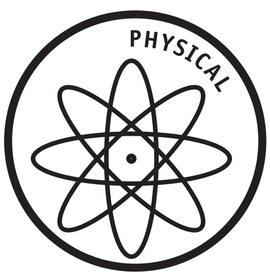


Alaska Science Content Standard A



Level 3, Ages 11–14

A student should understand scientific facts, concepts, principles, and theories.



Alaska Science Key Element A1

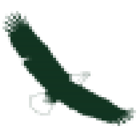
A student who meets the content standard should understand models describing the nature of molecules, atoms, and sub-atomic particles and the relation of the models to the structure and behavior of matter.

Performance Standard Level 3, Ages 11–14

Students develop and use models to demonstrate how atoms and elements form molecules and compounds, and how properties such as density can be measured and compared.

Sample Assessment Ideas

- Students identify the characteristics of the matter that goes into a campfire, and the characteristics of the final matter (ashes and smoke); ask students to conjecture about what happened and why.
- Students use toothpicks and gumdrops or marshmallows to build models of H_2, O_2, CO_2, CH_4, NH_3, and H_2O; identify the atomic color code used to build the models.



Expanded Sample Assessment Idea

- Students examine H_2O in three states; build models to represent the three states

Procedure

Students will:

1. Investigate snowflakes and the hexagonal structure of ice.
2. Experiment with ice, water, and steam using beakers, a thermometer, hot plate, and freezer. (Melt and refreeze ice cube; boil water, collect steam and refreeze ice cube.)
3. Graph temperature changes over time as ice melts to water and water heats up and boils
4. Build models representing H_2O molecules in solid, liquid and gas states; use the models to show how one state changes to another

Reflection and Revision

Which state has the greatest density? Which has the least density?

Level of Performance

Stage 4 — Student work is complete, correct, and shows evidence of logical reasoning. The models and explanations accurately reflect the structure, arrangement, and motion of H_2O in the three states.

Stage 3 — Student work may contain minor errors or omissions. The models and explanations reflect the structure, and motion of H_2O in the three states.

Stage 2 — Student work may contain errors of science fact and reasoning. The models and explanations may show evidence of skilled craftsmanship but may be incomplete, incorrect or lack detail.

Stage 1 — Student models and explanations are largely incomplete or incorrect.

Standards Cross-References

National Science Education Standards

Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanations on what they observed, and as they develop cognitive skills, they should be able to differentiate explanations from description—providing causes of effects and establishing relationships based on evidence and logical argument. (Page 145)

A substance has characteristic properties, such as density, boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties. (Page 154)

Benchmarks

Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous. (Page 269)

Mathematical models can be displayed on a computer and then modified to see what happens. (Page 269)

Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering. (Page 269)

All matter is made up of atoms, which are far too small to see directly through a microscope. The atoms of any elements are alike but are different from atoms of other elements. Atoms may stick together in well-defined molecules or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances. (Page 78)

Equal volumes of different substances usually have different weights. (Page 78)

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy and are free of one another except during occasional collisions. (Page 78)

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same. (Page 79)

Level 3

Alaska Science Key Element A2

A student who meets the content standard should understand the physical, chemical, and nuclear changes and interactions that result in observable changes in the properties of matter (Changes and Interactions of Matter).

Performance Standard Level 3, Ages 11–14

Students will explain changes that occur in physical and chemical properties of matter using a qualitative description of changes on a molecular level, including conservation of matter.

Sample Assessment Ideas

- Students identify the characteristics of matter that go into a campfire (logs, sticks, fuel, oxygen); observe the characteristics of the final matter (ashes, smoke, carbon dioxide); use chemical symbols and models to write the equation and demonstrate conservation of atoms for a simple combustion reaction of natural gas (CH_4 methane).
- Students predict and explain the flexibility, expansion or contraction of materials (such as snow machine tracks, sled runners, windshield materials, or mercury in a thermometer) under different extreme temperature conditions.

Standards Cross-References

National Science Education Standards

A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties. (Page 154)

Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group. (Page 154)

Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter. (Page 154)

Benchmarks

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy of motion, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy of motion and are free of one another except during occasional collisions. (Page 78)

The temperature and acidity of a solution influence reaction rates. Many substances dissolve in water, which may greatly facilitate reactions between them. (Page 78)

Scientific ideas about elements were borrowed from some Greek philosophers of 2000 years earlier, who believed that everything was made from four basic substance: air, earth, fire, and water. It was the combinations of these “elements” in different proportions that gave other substances their observable properties. The Greeks were wrong about those four, but now over 100 different elements have been identified, some rare and some plentiful, out of which everything is made. Because most elements tend to combine with others, few elements are found in their pure form. (Page 78)

There are groups of elements that have similar properties, including highly reactive metals, less reactive metals, highly reactive nonmetals (such as chlorine, fluorine, and oxygen), and some almost completely nonreactive gases (such as helium and neon). An especially important kind of reaction between substances involves combinations of oxygen with something else—as in burning or rusting. Some elements don't fit into any of the categories; among them are carbon and hydrogen, essential elements of living matter. (Page 78)

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same. The idea of atoms explains the conservation of matter: if the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same. (Page 79)

Alaska Science Key Element A3

A student who meets the content standard should understand models describing the composition, age, and size of our universe, galaxy, and solar system and understand that the universe is constantly moving and changing (Universe).

Performance Standard Level 3, Ages 11–14

Students collect and analyze data to create a model to explain motions of objects within our solar system and in relation to the Milky Way.

Sample Assessment Ideas

- Students describe the appearance and monthly motion of specific constellations in the night sky (which traditionally signified the change of seasons or movement of animals and fish) in terms of the background stars and Earth's rotation around the sun.
- Students design a scaled model of our solar system and identify our planet within the solar system.

Standards Cross-References

National Science Education Standards

The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph. (Page 154)

The Earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system. (Page 160)

Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses. (Page 160)

Benchmarks

The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. (Page 64)

The sun is many thousands of times closer to the Earth than any other star. Light from the sun takes a few minutes to reach the Earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the Earth. People on Earth, therefore, see them as they were that long ago in the past. (Page 64)

Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a great variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The Earth is orbited by one moon, many artificial satellites, and debris. (Page 64)

Large numbers of chunks of rock orbit the sun. Some of those that the Earth meets in its yearly orbit around the sun glow and disintegrate from friction as they plunge through the atmosphere and sometimes impact the ground. Other chunks of rocks mixed with ice have long, off-center orbits that carry them close to the sun, where the sun's radiation (of light and particles) boils off frozen material from their surfaces and pushes it into a long, illuminated tail. (Page 64)

We live on a relatively small planet, the third from the sun in the only system of planets definitely known to exist (although other, similar systems may be discovered in the universe). (Page 68)

Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous (Page 269)

Alaska Science Key Element A4

A student who meets the content standard should understand observable natural events such as tides, weather, seasons, and moon phases in terms of the structure and motion of the Earth (Earth).

Performance Standard Level 3, Ages 11–14

Students conduct research and make predictions about tides, weather, seasons, and phases of the moon and correlate these natural events to the motion of the Earth within our solar system.

Sample Assessment Ideas

- Students use the Internet to collect weather data (temperature, sunlight, and so on) from two sites on Earth; determine seasonal patterns of each site; explain the patterns in terms of the Earth's motion.
- Students discuss tide levels; explore differences in tide levels for coastal Alaska; estimate tide levels for various latitudes and longitudes

Expanded Sample Assessment Idea

- Students write a weather forecast using daily weather observations from multiple sources

Procedure

Students will:

1. Interview Elders to identify traditional weather-prediction systems
2. Collect weather data (including temperature, barometric pressure, wind speed and direction, humidity, and precipitation) from direct observation or from secondary sources.
3. Observe cloud formations and corresponding satellite weather pictures
4. Examine how the data correlates to weather patterns for the season and the year
5. Conduct Internet or library research to identify last year's weather patterns for the same week.
6. Write a forecast for the next week's weather and justify the prediction.
7. Share this information with the class

Reflection and Revision

What science and scientific concepts form the basis for an explanation of traditional weather predictions? What information or evidence was the most useful to predict the weather for the next week? What additional information could increase the accuracy of your weather prediction for the next week?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student weather forecast uses multiple information sources to predict the weather, and describes the value of information sources. Student work shows detailed relevant evidence of weather-related knowledge

Stage 3 — Student work is generally complete, and shows some evidence of logical reasoning. Student weather forecast uses several information sources to predict the weather and describes the value of some information sources. Student work shows evidence of relevant weather-related knowledge.

Stage 2 — Student weather forecast may contain evidence from several sources, but may be incomplete, incorrect, or lack detail. Student work shows limited evidence of weather-related knowledge, and may contain errors of science fact and reasoning.

Stage 1 — Student weather forecast and explanations are largely incomplete or incorrect, and demonstrate little or no evidence of weather-related knowledge. Forecast may contain errors of science fact and reasoning.

Standards Cross-References

National Science Education Standards

Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate because water in the oceans hold a large amount of heat. (Page 160)

Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses. (Page 160)

Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the Earth's surface and explains the phenomena of the tides. (Page 161)

The sun is the major source of energy for phenomena on the Earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the Earth's rotation on its axis and the length of the day. (Page 161)

Benchmarks

The Earth is mostly rock. Three-fourths of its surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin blanket of air. It is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the Earth's. (Page 68)

Everything on or anywhere near the Earth is pulled toward the Earth's center by gravitational force. (Page 69)

Because the Earth turns daily on an axis that is tilted relative to the plane of the Earth's yearly orbit around the sun, sunlight falls more intensely on different parts of the Earth during the year. The difference in heating of the Earth's surface produces the planet's seasons and weather patterns. (Page 69)

The moon's orbit around the Earth once in about 28 days changes what part of the moon is lighted by the sun and how much of that part can be seen from the Earth—the phases of the moon. (Page 69)

Climates have sometimes changed abruptly in the past as a result of changes in the Earth's crust, such as volcanic eruptions or impacts of huge rocks from space. Even relatively small changes in atmospheric or ocean content can have widespread effects on climate if the change lasts long enough. (Page 69)

The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the Earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean. (Page 69)

Heat energy created by ocean currents has a strong influence on climate around the world. (Page 69)

Alaska Science Key Element A5

A student who meets the content standard should understand the strength and effects of the forces of nature, including gravity and electromagnetic radiation (Forces of Nature).

Performance Standard Level 3, Ages 11–14

Students describe gravity as the force that governs orbital motion in the solar system and motion of the tides on the Earth, and describe light as radiation that travels in a straight line that can be reflected, refracted, or absorbed by matter.

Sample Assessment Ideas

- Students examine data on orbiting satellites and relate orbit size and period to velocity.
- Students make an Eskimo yo-yo and describe the similarity of its operation to the solar system, with gravitational force represented by the string.
- Students construct a model of the moon and Earth; use the model to demonstrate how high and low tides are formed.
- Students create a demonstration to show how a mixture of light of different colors can appear white

Standards Cross-References

National Science Education Standards

Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the Earth's surface and explains the phenomena of the tides. (Page 161)

Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object—emitted by or scattered from it—must enter the eye. (Page 155)

Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced. (Page 155)

The sun is a major source of energy for changes on the Earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the sun to the Earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation. (Page 155)

Benchmarks

Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors. (Page 90)

Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass. (Page 95)

The sun's gravitational pull holds the Earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them. (Page 95)

Electric currents and magnets can exert a force on each other. (Page 95)

Alaska Science Key Element A6

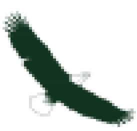
A student who meets the content standard should understand that forces of nature cause different types of motion, and describe the relationship between these forces and motion (Motion).

Performance Standard Level 3, Ages 11–14

Students analyze how balanced and unbalanced forces act on familiar objects and predict or explain changes in motion that may (or may not) occur.

Sample Assessment Ideas

- Students observe the blanket toss; describe and explain the motion of the object and the blanket at each stage; describe and explain the balance of forces at each stage.
- Students describe and explain forces and motion involved in bowling or other sports.



Expanded Sample Assessment Idea

- Students investigate how the force of gravity operates over a distance and influences the motion of a marble.

Materials

"Marbles" of different materials (ball bearings, glass marbles, plastic balls, etc.), thin card or wood to make "chutes", rulers or meter sticks.

Procedure

Students will:

1. Design and construct a chute that will roll marbles onto a table.
2. Roll a marble from different distances along the chute; measure the distance traveled on the table by the marble; record.
3. Repeat the marble roll to establish the reproducibility of the measurements.
4. Organize information into data tables; graph data.
5. Repeat steps 2–4 using different marbles, table surfaces, and so on.
6. Compare results with others in the class.
7. Draw diagrams to shows the forces and resulting motion acting on the marble before it is released, as it is rolling down the chute, when it reaches the table, as it is rolling along the table, and when it stops moving on the table.

Reflection and Revision

How reproducible is the experiment? What causes the variability? How can the procedure be improved to reduce the variability? How do the results change if you change the surface of the table? The type of marble? What causes these changes? What is the pattern that describes how the distance the marble moves across the table is related to the distance from which it was rolled off the chute? What other variables (besides distance along the length of the chute) might affect the distance the marble travels across the table?

Levels of Performance

Stage 4 — Student work is complete, correct, and shows detailed evidence of the transfer and extension of knowledge that relates forces to changes in motion. Data tables and graphs are clearly labeled, well-organized and accurately represent the observations. All five force diagrams are clearly labeled to show the appropriate forces and resulting motion. The discussion shows excellent reasoning skills, recognizes that the amount of "force" determines the motion, that a constant force (gravity) is applied down the chute, and that no new force is applied once the marble leaves the bottom of the chute, and includes a detailed error analysis section.

Stage 3 Student work is mostly correct, and shows evidence of the transfer or extension of knowledge that relates forces to changes in motion. Data tables and graphs are labeled, organized and reasonable representations of the observations. Most of the force diagrams are labeled to show the appropriate force and resulting motion, although they may contain minor errors or omissions. The discussion shows reasoning skills, recognizes that force determines the motion, that a constant force (gravity) is applied down the chute, and includes an error analysis section.

Stage 2 Student records some data and attempts to graph. In discussion shows limited logical reasoning. May not recognize clearly the amount or origin of "force" that determines results, or that other variables need to be controlled. May recognize that some variables need to be controlled, but is unclear on details.

Stage 1 Student work is mostly incomplete, contains misconceptions relating to force and motion, data records are minimal or totally incorrect, and interpretations show limited scientific reasoning.

Standards Cross-References

National Science Education Standards

The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph. (Page 154)

An object that is not being subjected to a force will continue to move at a constant speed and in a straight line. (Page 154)

If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion. (Page 154)

Benchmarks

An unbalanced force acting on an object changes its speed or direction of motion, or both. If the force acts toward a single center, the object's path may curve into an orbit around the center. (Page 90)

Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials. (Page 90)

Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation—visible light. Differences of wavelength within that range are perceived as differences in color. (Page 90)

Level 3

Alaska Science Key Element A7

A student who meets the content standard should understand how the Earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things (Processes that Shape the Earth).

Performance Standard Level 3, Ages 11–14

Students use models to explain how large scale movements within the Earth's interior cause changes on the Earth's surface.

Sample Assessment Ideas

- Students design and draw a 2-dimensional model or construct a 3-dimensional model that represents a convection current within the Earth, describe the cyclic pattern of movement.
- Students create a model of tectonic plates and hypothesize how the Alaskan landmass, and the Chilkoot and Brooks Ranges were formed.

Expanded Sample Assessment Idea

- Students design and create a model that shows the relationship between convection currents within the Earth's mantle, large-scale motions of the Earth's interior, and subsequent effects on the Earth's surface.

Procedure

Students will:

1. Work in small groups to decide the format for their model (for example, drawing, flip book, diorama, cut-away sphere, computer graphic, computer simulation, or video) that will demonstrate the relationship between interior motion and surface changes of the Earth.
2. Choose the type of surface change their model will simulate.
3. Design and construct their model.
4. Make a formal presentation to the class that demonstrates the relationship between convention currents in the mantle, large-scale motions of the Earth's interior, and subsequent surface change.
5. Discuss how different large-scale motions of Earth's interior produce different landforms on the Earth's surface.

Reflection and Revision

Use the models as a reference for discussion about landform groupings around the Earth. Why do volcanic mountains appear to form in clusters?

Level of Performance

Stage 4 — Student model is complete, detailed, and accurately describes the relationship between convection currents within the Earth's mantle, large-scale motions of the Earth's interior, and the subsequent effect of the Earth's surface. Student explanation demonstrates evidence of higher-level thinking and relevant knowledge. There is no evidence of misconceptions.

Stage 3 — Student model is complete, and accurately describes some relationships between convection currents within the Earth's mantle, large-scale motions of the Earth's interior, and subsequent effects on the Earth's surface. Student explanation demonstrates evidence of higher-level thinking or relevant knowledge. Minor misconceptions may be present.

Stage 2	Student model includes convection currents, large-scale interior movements, or surface changes, but does not demonstrate the relationship between them.	Stage 1	Student may attempt to construct a model, but the work lacks detail, is incomplete, or inaccurate. Student explanation shows evidence of major misconceptions.

Standards Cross-References

National Science Education Standards

The solid Earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core. (Page 159)

Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building result from these plate motions. (Page 160)

Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion. (Page 160)

Some changes in the solid Earth can be described as the "rock cycle." Old rocks at the Earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues. (Page 160)

Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture. (Page 160)

Water, which covers the majority of the Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the Earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. (Page 160)

Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans. (Page 160)

Living organisms have played many roles in the Earths' system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks. (Page 160)

The Earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. Earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet. (Page 160)

Benchmarks

The interior of the Earth is hot. Heat flow and movement of material within the Earth cause earthquakes and volcanic eruptions and create mountains and ocean basins. Gas and dust from large volcanoes can change the atmosphere. (Page 73)

Some changes in the Earth's surface are abrupt (such as earthquakes and volcanic eruptions) while other changes happen very slowly (such as uplift and wearing down of mountains). The Earth's surface is shaped in part by the motion of water and wind over very long times which act to level mountain ranges. (Page 73)

Sediments of sand and smaller particles (sometimes containing the remains of organisms) are gradually buried and are cemented together by dissolved minerals to form solid rock again. (Page 73)

Sedimentary rock buried deep enough may be reformed by pressure and heat perhaps melting and recrystallizing into different kinds of rock. These reformed rock layers may be forced up again to become land surface and even mountains. Subsequently, this new rock too will erode. Rock bears evidence of the minerals, temperature, and forces that created it. (Page 73)

Thousands of layers of sedimentary rock confirm the long history of the changing surface of the Earth and the changing life forms whose remains are found in successive layers. The youngest layers are not always found on top, because of folding, breaking, and uplift of layers. (Page 73)

Although weathered rock is the basic component of soil, the composition and texture of soil and its fertility and resistance to erosion are greatly influenced by plant roots and debris, bacteria, fungi, worms, insects, rodents, and other organisms. (Page 73)

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the Earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms. (Page 73)

Mini-Unit: Plates on the Move

Performance Standard A7, Level 3

Students will use models to explain how large scale movements within the Earth's interior cause changes on the Earth's surface.

Key Concepts and Skills

- Solid earth is divided into several layers: a thin crust, the solid lithosphere, the mantle layer, and a dense metal core.
- Heat flow and convection currents within the mantle cause motion of the lithospheric plates; continental plates and the ocean floor move at rates of centimeters per year.
- Major geological events such as earthquakes, volcanic eruptions, and mountain building are the result of motion of the tectonic plates.
- Skills: Observe, develop models and hypotheses, experiment, communicate; transfer concepts, record data, summarize data, interpret data, report orally; use reference materials, deliver a presentation, measure, sketch, write, compare, plan, design.

Timeline

Up to twenty days, not consecutive

Abstract

Students will develop their understanding of plate tectonics using hands-on activities, information searches, guided discussion, and content expertise from the teacher or other subject-matter expert.

Alaska Science Content Standard Key Element

A student who meets the content standard should understand how the earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things.

Cross-References

Additional Content and Performance Standards: A6, B1
Integration: This topic can be used to reinforce and complement math, reading, language, social studies, and art skills.

Materials

- ✔ Include a variety of materials in your classroom as an invitation to learn and use later to generalize Some materials include; read-aloud stories, Native stories, personal stories, news articles, slides and illustrations of earthquakes and volcanoes, and so on.
- ✔ The Alaska Resources Kit: Minerals & Energy (AMEREF); Module B, Alaska's Geology; available from Alaska Department of Education
- ✔ Perfume, ammonia, or other volatile, odorous substances
- ✔ Hot plate or other means to create hot water
- ✔ Clear plastic shoe box, glass tank, aquarium, or clear glass bread pan
- ✔ Ice, food dye, small paper cup, masking tape, water source
- ✔ Apple for Scale Model Activity
- ✔ Media resources: USGS '64 quake or other geohazard slides, photos, books, Internet, CD-ROM
- ✔ Craft materials to use in student models

Activities

Ongoing Background Student Activity

From week 1 through week 30 of the school year, record and map earthquake and volcano occurrence data on individual student maps and a large classroom map.

Gear-up

Move all students to one side of the classroom. Blindfold them. Open a bottle of perfume, ammonia or sufficiently odorous substance on the opposite side of the classroom. Measure the time it takes the odor to reach the students. Repeat the experiment. This time put the odor-causing substance on a hot plate. Ask students to speculate how the odor traveled from the container across the room to their location. Describe kinetic-molecular theory and relate it to the odor demonstration. Students draw a magnified molecular view of the odor demonstration using cartoon-type molecular characters. Show students pictures, tell stories, ask if they have experienced earthquakes. Ask students to speculate how the odor demonstration relates to earthquakes.

Embedded Assessment

The demonstration, discussion, drawing and speculation are part of embedded pre-assessments to determine student understanding, previous learning, and possible misconceptions.

1

Discuss in small-groups what students know or think they know about the earth's interior structure. Elicit questions about those topics students want to know more about. Ask students how an apple is similar to the earth. Use the apple as a starting point to discuss the structure of the earth's interior. Cut an apple in half and use it to refer to the core, layers, and crust of the earth. (See AMEREF Module B for graphic. Similar graphics can be found in texts, and the FEMA Earthquake Book.)

2

Students investigate convection currents by using a heat sink (cup of ice) or heat source (container of hot water on hot plate) to observe movement of dye in water. This activity may be modified by floating "continent cut-outs" on the water surface. (See AMEREF Module B.)

Embedded Assessment: Students draw a diagram to show vertical and horizontal views of convection currents. Use the molecular cartoon characters created during Gear-Up activities to explain what causes convection currents.

3

Students use a world map as a discussion reference to discover possible geographic land matches such as the Atlantic coasts of South America and Africa. Put together a jigsaw puzzle that illustrates global plate boundaries. (AMEREF Module B Plate Tectonic Puzzle.)

4

Collect and share information about the effects of earth's crustal plate movements. (Sources include: materials from United States Geological Survey (USGS), slides, magazine pictures, newspaper, Web search, stories from Elders, and so on). Use student-generated information as well as information from subject-matter experts (teacher, USGS personnel and so on) to tie together the concept of convection as it relates to interior earth movements, and the large-scale surface effects of plate movements.

Embedded Assessment

Students use words or words and pictures to explain how convection currents cause large-scale movements on the earths' surface.

Expanded Sample Assessment Idea

Students design and create a model that shows the relationship between convection currents within the earth's mantle, large-scale motions of the earth's interior, and subsequent effects on the earth's surface.

Procedure

Students will:

1. Work in small groups to decide the format for their model (for example, drawing, flip book, diorama, cut-away sphere, computer graphic, computer simulation, or video) that will demonstrate the relationship between interior motion and surface changes of the earth.
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Reflection and Revision

Use the models as a reference for discussion about landform grouping around the earth. Why do volcanic mountains appear to form in clusters?

Level of Performance:

Stage 4 — Student model is complete, detailed, and accurately describes the relationship between convection currents within the Earth's mantle, large-scale motions of the Earth's interior, and the subsequent effect of the Earth's surface. Student explanation demonstrates evidence of higher-level thinking and relevant knowledge. There is no evidence of misconceptions.

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Alaska Science Key Element A8a

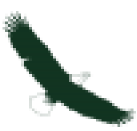
A student who meets the content standard should understand the scientific principles and models that describe the nature of physical, chemical, and nuclear reactions (Energy Transformations).

Performance Standard Level 3, Ages 11–14

Students investigate common physical and chemical changes and the characteristics associated with each type of change, and relate these changes to simple rearrangements of atoms.

Sample Assessment Ideas

- Students conduct tests with cabbage juice indicator and common household substances to determine if they are an acid or a base
- Students compare cookies or cake recipe ingredients (or mix) with the cooked product; compare taste, smell, texture and appearance; explain what happened in terms of irreversible chemical changes



Expanded Sample Assessment Idea

- Students investigate the reaction of iron and sulfur to form iron sulfide and build structural models to help explain the reaction and the conservation rules involved

Materials

- ✔ test tubes
- ✔ iron filings
- ✔ magnet
- ✔ balance (if available)
- ✔ heater (Bunsen burner or flame)
- ✔ sulfur powder
- ✔ magnifying glass

Procedure

NOTE: Proper safety procedures must be followed!

Students will:

1. Make careful observation of the properties of iron filings and sulfur (including: hardness, color, crystal shape, magnetic properties, solubility/reaction in water); make quantitative measurements of the mass of the iron filings and sulfur; describe and record in journal.
2. Add one scoop of each starting material into a test tube, and heat strongly **(SAFETY NOTE—take care not to catch sulfur on fire)**; cool.
3. Make careful observation of the properties of the product removed from the test tube (including: hardness, color, crystal shape, magnetic properties, solubility/reaction in water); make quantitative measurements of the mass of the product; describe and record in journal.
4. Build models of iron, sulfur and iron sulfide; use the models to discuss physical and chemical properties, and physical and chemical changes

Reflection and Revision

What properties do the substances have in common? What properties are different? What is the evidence for physical change? What is the evidence of chemical change? Explain why some students find that the product is magnetic and some do not.

Levels of Performance

Student work is complete, correct and shows evidence of logical reasoning and the transfer and extension of knowledge regarding chemical vs. physical change and properties. Student work includes detailed observations and accurate models that demonstrate the conservation of atoms in chemical reactions The models are used to interpret experimental observations including the presence of non-reacted materials and the principle that correct ratios are required for a complete reaction.

Stage 3 Student work is mostly complete and shows evidence of reasoning and the transfer or extension of knowledge regarding chemical vs physical change and properties Student work may contain minor errors or omissions but it includes some detailed observations as well as models that demonstrate the interaction of atoms in chemical reactions The models are used to explain some experimental observations and the need for correct ratios

Stage 2 Student work may be incomplete, and shows limited evidence of knowledge regarding the difference between physical and chemical properties or changes Experimental observations lack detail, models may show evidence of skilled craftsmanship but flawed reasoning is used to explain chemical reactions

Stage 1 Student work is mostly incomplete and shows evidence of misconceptions regarding physical and chemical properties and changes Observations are minimal or totally incorrect and models may be incorrect or cannot be used to explain chemical reactions

Standards Cross-References

National Science Education Standards

Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group. (Page 154)

Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter. (Page 154)

In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers. (Page 155)

Benchmarks

Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. In solids, the atoms are closely locked in position and can only vibrate. In liquids, the atoms or molecules have higher energy of motion, are more loosely connected, and can slide past one another; some molecules may get enough energy to escape into a gas. In gases, the atoms or molecules have still more energy of motion and are free of one another except during occasional collisions (Page 78)

There are groups of elements that have similar properties, including highly reactive metals, less reactive metals, highly reactive nonmetals (such as chlorine, fluorine, and oxygen), and some almost completely nonreactive gases (such as helium and neon). An especially important kind of reaction between substances involves combinations of oxygen with something else—as in burning or rusting. Some elements don't fit into any of the categories; among them are carbon and hydrogen, essential elements of living matter. (Page 78)

No matter how substances within a closed system interact with one another, or how they combine or break apart, the total weight of the system remains the same The idea of atoms explains the conservation of matter: if the number of atoms stays the same no matter how they are rearranged, then their total mass stays the same. (Page 79)

Level 3

Alaska Science Key Element A8b

A student who meets the content standard should understand the scientific principles and models that state whenever energy is reduced in one place, it is increased somewhere else by the same amount (Energy Transformations).

Performance Standard Level 3, Ages 11–14

Students observe and describe energy changes that take place around them.

Sample Assessment Ideas

- Students draw a diagram to show the flow of energy from the fuel used in the local generator to the electric light in their respective homes
- Students research the energy efficiency of their home and develop multiple suggestions as to how to improve the heat efficiency of their respective homes

Expanded Sample Assessment Idea

- Students create a model of a steam house; measure the temperature changes; explain the energy transfers [Proper SAFETY precautions should be used.]

Procedure

Students will:

1. Build a model of a steam house or steam tent.
2. Measure the weight of a length of metal chain.
3. Heat the metal chain on a hot plate (Note: chain makes a good substitute for rocks which sometimes explode when heated.)
4. Remove the chain and place it inside the model.
5. Carefully pour a measured amount of water over the chain.
6. Measure the increase in temperature inside the model.
7. Explain how the temperature measurement and calculations describe each of the energy releases and transfers. (Be sure to include the energy needed to turn liquid water into water vapor)

Reflection and Revision

Discuss energy transfer by radiation, conduction and convection. Give examples in nature of where these energy transfers occur. Give examples of where these energy transfers occur in our technological world.

Levels of Performance

Stage 4 Student work is complete, correct and shows detailed evidence of the transfer and extension of knowledge related to energy changes that take place around us. The experiment is performed safely, data is represented with appropriate units, explanation is accurate and describes examples of radiation, conduction and convection in the natural environment as well as in the technological world..

Stage 3 Student work is mostly complete, correct and shows evidence of the transfer or extension of knowledge related to energy changes that take place around us, but may contain minor errors or omissions.. The experiment is performed safely, data may not include appropriate units, and the explanation describes at least two examples of radiation, conduction or convection in the natural environment or in the technological world, although it may contain minor errors or omissions

Stage 2 — Student work may be incomplete, and shows limited evidence of knowledge related to energy changes that take place around us. The experiment is performed safely and model may show evidence of skilled craftsmanship but data is incomplete or incorrect, and the explanation may contain misconceptions

Stage 1 — Student work is mostly incomplete, inappropriate, shows little evidence of craftsmanship or knowledge related to energy changes that take place around us.

Standards Cross-References

National Science Education Standards

Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. (Page 155)

Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced. (Page 155)

In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers. (Page 155)

The sun is a major source of energy for changes on the Earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the sun to the Earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation. (Page 155)

Benchmarks

Energy cannot be created or destroyed, but only changed from one form into another. (Page 85)

Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation. (Page 85)

Energy appears in different forms. Heat energy is in the disorderly motion of molecules; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; gravitational energy is in the separation of mutually attracting masses. (Page 85)

Alaska Science Key Element A8c

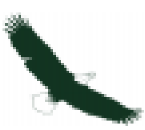
A student who meets the content standard should understand the scientific principles and models that state that whenever there is a transformation of energy, some energy is spent in ways that make it unavailable for use (Energy Transformations).

Performance Standard Level 3, Ages 11–14

Students examine energy transfers and identify energy that is useful vs. energy that is unavailable.

Sample Assessment Ideas

- Students identify energy transformations in the community (school and home especially); design a way to measure the efficiency of an energy transfer (e.g. electricity to light); confirm what happens to the "lost" energy.
- Students research and report on the efficiency of light bulbs, refrigerators, and other household or community appliances; contact local appliance stores for this information or write to the manufacturer; describe what happens to the remaining energy (e.g. if a light bulb is 40% efficient, what happens to the other 60%?)



Expanded Sample Assessment Idea

- Students carry out a standard calorimetry experiment to compare energy losses in different calorimeters.

Materials

- ✔ hot plate
- ✔ metal blocks with holes for thermometer
- ✔ tongs
- ✔ calorimeters
  (styrofoam cup and lid with hole for thermometer)

Procedure

Students will:

1. Measure the volume of water required to fill calorimeter half-full of water; heat this amount of water to near boiling.
2. Weigh the metal block; insert thermometer and measure temperature of metal block; record measurements.
3. Determine the "calorimeter constant" (i.e. quickly add a known volume of water at a known temperature to the calorimeter; measure the immediate drop in temperature; calculate the heat needed to heat the calorimeter from room temperature to the temperature just measured.)
4. Place the metal block at known temperature into the hot water in the calorimeter; measure the temperature change over a few minutes; record data.
5. Graph data; extrapolate back to "zero time" to get specific change in temperature.
6. Graph the calorimeter's heat loss over time.
7. Compare results with other students in class.

Reflection and Revision

What are the efficiencies (heat retained or total heat loss) for the different calorimeters? Where happens to the heat energy that is "lost" from the calorimeter? How could you change the design to improve the efficiency of your calorimeter? How can this information about efficiency and heat loss be used in an application in the community?

Levels of Performance

Stage 4 Student work is complete and shows clear evidence of ability to conduct a reproducible experiment to measure heat loss. Data and observations are recorded in detail, graphs accurately represent the data, and the student describes an appropriate method to reduce the heat loss of the calorimeter. Community applications are discussed in detail and show extensive evidence of the transfer of knowledge.

Stage 3 Student work is mostly complete and shows evidence of ability to conduct a reproducible experiment to measure heat loss. Data and observations are recorded, graphs are drawn to represent the data, and the student describes a method to reduce the heat loss of the calorimeter. An example of a community application is discussed and shows evidence of transfer of knowledge.

Stage 2 Student work may be incomplete and shows limited evidence of ability to conduct a reproducible experiment or measure heat loss. Data and observations are recorded but errors are made. Student may not include suggestion for improving the measurements. Student may identify a community application but the explanation lacks detail and show limited transfer of knowledge.

Stage 1 Student work is mostly incomplete and shows misconceptions regarding experimental design and heat loss. Data and observations are incomplete or incorrectly recorded. Community applications, if present are incorrect and show evidence of misconceptions.

Standards Cross-References

National Science Education Standards

In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers. (Page 155)

The sun is a major source of energy for changes on the Earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the sun to the Earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation. (Page 155)

Benchmarks

Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation. (Page 85)

Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid currents will be set up in it that aid the transfer of heat. (Page 85)

Level 3

Alaska Science Key Element A9

A student who meets the content standard should understand the transfers and transformations of matter and energy that link living things and their physical environment from molecules to ecosystems (Flow of Matter and Energy).

Performance Standard Level 3, Ages 11–14

Students create an ecosystem and explain physical and chemical changes that take place as energy flows and matter cycles within that ecosystem.

Sample Assessment Ideas

- Students use role play to demonstrate a food web that consists of at least five organisms; discuss interrelationships and how each organism contributes to the survival of the others.

Expanded Sample Assessment Idea

- Students create a model biosphere and explain the physical and chemical changes taking place within each component.

Procedure

Students will:

1. Create a total living environment that includes producers, consumers, and decomposers. (*Bottle Biology* describes several terrestrial and aquatic biospheres made with recycled soda-pop plastic bottles.)
2. Record observations made with naked eye, hand lens, and microscope, as appropriate.
3. Create a visual display (such as a poster, 3-D model, computer graphic, or computer simulation) that describes the cycling of matter and flow of energy in their biosphere.

Reflection and Revision

How would the biosphere have been affected if you started it with twice as many producers? Predict the effect of removing one of the organisms. Predict the effect of damaging one of the components? What would change if the model biosphere was located inside a spaceship?

Levels of Performance

Stage 4 Student work is complete, shows evidence of logical reasoning and extensive evidence of knowledge regarding physical and chemical changes that take place within an ecosystem. The visual display includes a detailed description of the physical and chemical effects of each component of the biosphere, the flow of energy and cycling of matter within the biosphere, and a detailed prediction of what would happen if one of the components were removed or damaged.

Stage 3 Student work is complete and shows evidence of logical reasoning and the physical and chemical changes that take place within an ecosystem, although it may also contain omissions and minor inaccuracies. The visual display includes a description of the physical and chemical effects of components of the biosphere, a description of the flow of energy or cycling matter within the system and a partial description or prediction about the effect of removal of one of the components.

Stage 2 Student work may contain evidence of skilled craftsmanship, but is incomplete, may contain errors of reasoning or misconceptions regarding the components of a biosphere.

Stage 1 Student work may contain evidence of skilled craftsmanship but is largely incomplete, incorrect, and may contain major misconceptions regarding the biosphere.

Standards Cross-References

National Science Education Standards

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. (Page 157)

For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. (Page 158)

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. (Page 158)

Benchmarks

Food provides molecules that serve as the fuel and the building material for all organisms. Plants use the energy from light to make sugars from carbon dioxide and water. This food can be used immediately or stored for later use. Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive. (Page 120)

Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change. (Page 120)

Energy can change from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. Almost all food energy comes originally from sunlight. (Page 120)

Level 3

Alaska Science Key Element A10

A student who meets the content standard should understand that living things are made up mostly of cells and that all life processes occur in cells (Cells).

Performance Standard Level 3, Ages 11–14

Students create models to describe the basic structure of plant and animal cells, how cells organize to form tissues, how tissues form organs, and how organs form organ systems within multicellular organisms.

Sample Assessment Ideas

- Students illustrate the different shapes of specialized cells; relate the shape to the specialized function of each cell.
- Students draw or build a model of a root, stem, or leaf along with one or more tissues and cells that make up that structure.
- Students create a diagram that shows the relationship between the heart and circulatory system.

Standards Cross-References

National Science Education Standards

Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs. (Page 156)

Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole. (Page 156)

Benchmarks

All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants. (Page 112)

Cells repeatedly divide to make more cells for growth and repair. Various organs and tissues function to serve the needs of cells for food, air, and waste removal. (Page 112)

Within cells, many of the basic functions of organisms—such as extracting energy from food and getting rid of waste—are carried out. The way in which cells function is similar in all living organisms. (Page 112)

About two-thirds of the weight of cells is accounted for by water, which gives cells many of their properties. (Page 112)

Alaska Science Key Element A11

A student who meets the content standard should understand that similar features are passed on by genes through reproduction (Heredity).

Performance Standard Level 3, Ages 11–14

Students explain the similarities and differences between sexual and asexual reproduction in a variety of organisms.

Sample Assessment Ideas

- Students describe sexual and asexual reproduction methods in plants, including production of seeds and runners.
- Students develop a model to show the cellular differences between mitosis and meiosis.

Standards Cross-References

National Science Education Standards

Plants and animals closely resemble their parents. (Page 129)

Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation. (Page 129)

The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment. (Page 157)

Benchmarks

In some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent. (Page 108)

In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell. (Page 108)

Alaska Science Key Element A12

A student who meets the content standard should distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life and understand the theories that describe the importance of diversity for species and ecosystems (Diversity).

Performance Standard Level 3, Ages 11–14

Students organize living organisms into groups based on internal and external structure, reproductive style, and their place in the food web.

Sample Assessment Ideas

- Students produce a poster explaining a food web; participate in a class presentation that demonstrates how roles are filled by different organisms in different food webs.
- Students research an animal from a local environment; examine internal and external structure, reproductive patterns, relationships to other organisms, and related animals found in other global environments.

Standards Cross-References

National Science Education Standards

Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry. (Page 158)

Benchmarks

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, can not be neatly classified as either plants or animals. (Page 104)

Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce. (Page 104)

Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance. (Page 104)

For sexually reproducing organisms, a species comprises all organisms that can mate with one another to produce fertile offspring. (Page 104)

All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment. (Page 104)

Alaska Science
Key Element A13

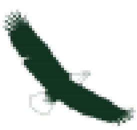
A student who meets the content standard should understand the theory of natural selection as an explanation for evidence of changes in life forms over time (Evolution and Natural Selection).

Performance Standard Level 3, Ages 11–14

Students use information found in the fossil record to provide evidence for the history of Earth and its changing life forms.

Sample Assessment Ideas

- Students use sets of cards with preprinted information relating to fossils and geologic events, to organize a time line.
- Students describe how a variety of organisms (including plants, animals, and insects) become fossils; examine how fossil evidence gives information about organisms



Expanded Sample Assessment Idea

- Students use a set of fossilized footprints to conjecture what might have occurred; compare results of their speculations.

Procedure

Students will:

1. Analyze a set of fossilized tracks; use the available evidence to reconstruct a series of events.
2. As a class, discuss alternative explanations; differentiate between evidence and inference
3. Design their own footprint puzzle; give it to another group to analyze.
4. Diagram footprint evidence that could lead to several different, yet defensible, explanations regarding the specific event that took place involving the two or more people or animals from the puzzle
5. Students participate in a mock scientific conference in which they defend their best explanation for what happened after studying the fossil footprint puzzle.

Reflection and Revision

Explain the strengths and weaknesses of each explanation.

Level of Performance

Stage 4 — Student work shows extensive evidence of knowledge regarding fossil tracks and animal behavior. Explanations are complete, correct, and give several different, yet defensible, explanations regarding what took place in the footprint puzzle.

Stage 3 — Student work shows evidence of knowledge regarding fossil tracks and animal behavior. Explanations are complete, but minor errors may be present, or a limited explanation is given for what took place in the footprint puzzle

Stage 2 — Student work shows limited evidence of knowledge regarding fossil tracks. Explanations are incomplete and may contain significant errors.

Stage 1 — Student work shows little or no evidence of knowledge and regarding fossil tracks and major misconceptions are evident.

Standards Cross-References

National Science Education Standards

Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment. (Page 158)

Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the Earth no longer exist. (Page 158)

Benchmarks

Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors (Page 124)

Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species. (Page 124)

Many thousands of layers of sedimentary rock provide evidence for the long history of the Earth and for the long history of changing life forms whose remains are found in the rocks. More recently deposited rock layers are more likely to contain fossils resembling existing species. (Page 124)

Level 3

Alaska Science Key Element A14a

A student who meets the content standard should understand the interdependence between living things and their environments (Interdependence).

Performance Standard Level 3, Ages 11–14

Students classify living organisms based on their position and function in a complex food web.

Sample Assessment Ideas

- Students discuss the short-term and long-term consequences of removing a specific organism from a food web.
- Students describe the relationship of bacteria and plants in the nitrogen cycle.

Expanded Sample Assessment Idea

- Students report on a predatory animal in their local area; determine which other predators are in direct competition for food.

Procedure

Students will:

1. Choose an animal to study.
2. Make observations, do library and Internet research, contact state park agencies for information, and discuss their assignments with knowledgeable Elders; determine what prey animals these predators eat, and how much territory is required to support each predator.
3. Identify inter-species and intra-species predators in direct competition with one another for food.
4. Illustrate and describe the food chain of the animal.
5. Produce a class poster, written, or oral class report. (The list of predators in an area could become unmanageable if insects are included. Teachers will have to set some limits on types of animals under consideration.)
6. Compare and classify the animals in the food web according to the level they occupy in the food chain.

Reflection and Revision

Describe the changes that would occur if one predator or one prey were removed from this area? How would other organisms in the food chain be affected? What happens to human consumption when one food animal is no longer available? Why are some predators no longer found in their original area or in our community?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of clear and logical reasoning. Student conducts a thorough investigation of an animal and produces a detailed food web that includes organisms from all trophic levels of the food chain. Student correctly identifies predators in direct competition with one another and explains how these animals avoid direct competition. Student work shows extensive evidence of transfer and extension of knowledge in a detailed discussion of how an organism's change affects the food web.

Stage 3 — Student work shows evidence of logical reasoning, but may contain minor errors or omissions. Student conducts an investigation of an animal and produces a food web that includes organisms from all trophic levels of the food chain. Student correctly identifies predators in direct competition with one another and explains how two of these animals avoid direct competition. Student work shows evidence of transfer and extension of knowledge in a discussion of how an organism's change affects the food web.

Stage 2 — Student work may be incomplete, or contain errors of science fact and reasoning. Student conducts an investigation of an animal and produces a simple food chain. Student may identify another animal that competes for food or other resources. Student work shows limited evidence of transfer and extension of knowledge.

Stage 1 — Student work is largely incomplete, and may contain major misconceptions regarding an animal and its needs or complex food chain.

Standards Cross-References

National Science Education Standards

Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems. (Page 156)

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. (Page 157)

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. (Page 158)

Benchmarks

In all environments-freshwater, marine, forest, desert, grassland, mountain and others-organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical condition. (Page 117)

Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other. (Page 117)

Level 3

Alaska Science Key Element A14b

A student who meets the content standard should understand that the living environment consists of individuals, populations, and communities (Interdependence).

Performance Standard Level 3, Ages 11–14

Students describe the interactions of individuals within a population.

Sample Assessment Ideas

- Students investigate moose, caribou, or deer hunting regulations in the state of Alaska; determine how the state defines hunting areas, the restrictions in each area, and why the state agencies regulate different sections of the state as they do; compare state regulations to traditional co-management practices
- Students identify the performance characteristics of the alpha female and other members of a wolf pack.

Expanded Sample Assessment Ideas

- Students estimate the number of individuals of a species in a well-defined area, using common biological methods of counting and extrapolation.

Procedure

Students will:

1. Visit a local habitat to observe quantifiable wildlife (for example, mussels on a beach, slugs in a plot).
2. Measure and mark off an area in which to count the number of organisms of a particular species
3. Extrapolate their count to the area of the habitat.
4. Compare and combine class results

Reflection and Revision

Are there variations within the class? What would improve the accuracy of the count? How could you determine the population for a larger region, for example, the state of Alaska? What limits the number of organisms?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student performs a careful, well-documented count of individuals using standard techniques, and correctly extrapolates to the entire area under consideration. Student describes an extrapolation method to cover across a greater region and discusses methods to improve the accuracy of the data.

Stage 3 — Student work shows evidence of logical reasoning but may contain minor errors or omissions. Student performs a careful count of individuals, using standard techniques, and correctly extrapolates to the entire area under consideration.

Stage 2 — Student work may be incomplete, or contain errors of science fact and reasoning. Student performs a count of individuals and may extrapolate to a larger area.

Stage 1 — Student work may perform a cursory count of individuals but work is largely incomplete, may contain major misconceptions, and show little evidence of understanding.

Standards Cross-References

National Science Education Standards

A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. (Page 157)

Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some microorganisms are producers-they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. (Page 157)

Benchmarks

All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment. (Page 104)

Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other (Page 117)

Alaska Science Key Element A14c

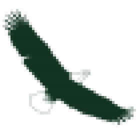
A student who meets the content standard should understand that a small change in a portion of an environment may affect the entire environment (Interdependence).

Performance Standard Level 3, Ages 11–14

Students predict how a shortage or excess of resources affects organisms in higher trophic levels.

Sample Assessment Ideas

- Students examine how a single change in a food web effects all the plants and animals in that food web.



Expanded Sample Assessment Ideas

- Students investigate an animal's food preferences under ideal conditions and difficult conditions.

Procedure

Students will:

1. Form small groups; each member will choose a component of a food web.
2. Investigate an animal's food preferences, under ideal and difficult conditions.
3. Rank the animals according to their potential to survive harsh conditions or adapt to a new habitat.
4. Report findings to the class.

Reflection and Revision

What would happen if there was an abundance of food available?

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Student report includes a thorough investigation of the animals' food needs, eating habits and ability to adapt to new or stressful environmental conditions.

Stage 3 — Student work shows evidence of logical reasoning but may contain minor errors or omissions. Student report includes an investigation of the animals' food needs, eating habits, and ability to adapt to new or stressful environmental conditions.

Stage 2 — Student report may include the eating habits of the animal, but may be incomplete, and contain errors of science fact and reasoning.

Stage 1 — Student report is incomplete, and may contain major misconceptions.

Standards Cross-References

National Science Education Standards

Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms.

Behavioral response is a set of actions determined in part by heredity and in part from experience. (Page 157)

An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history. (Page 157)

The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. (Page 158)

Benchmarks

In all environments-freshwater, marine, forest, desert, grassland, mountain and others-organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical condition. (Page 117)

Climates have sometimes changed abruptly in the past as a result of changes in the Earth's crust, such as volcanic eruptions or impacts of huge rocks from space. Even relatively small changes in atmospheric or ocean content can have widespread effects on climate if the change lasts long enough. (Page 69)

Fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life. (Page 69)

The benefits of the Earth's resources-such as fresh water, air, soil, and trees-can be reduced by using them wastefully or by deliberately or inadvertently destroying them. The atmosphere and the oceans have a limited capacity to absorb wastes and recycle materials naturally. Cleaning up polluted air, water, or soil or restoring depleted soil, forests, or fishing grounds can be very difficult and costly. (Page 69)

Alaska Science Key Element A15

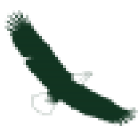
A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

Performance Standard Level 3, Ages 11–14

Students conduct research to learn how the local environment is used by a variety of competing interests including local plant and animal populations, individual families, the local community, and outside sources such as oil and mining companies, hunting groups, and tourists.

Sample Assessment Ideas

- Students take a field trip to a local beaver pond; note evidence of animals, types of plant life, types of fish, soil conditions, and so on; predict what might happen to the stream habitat if beavers move in.



Expanded Sample Assessment Idea

- Students develop a model plan to maximize the benefits and minimize the negatives of managing local fish or wildlife

Procedure

Students will:

1. Brainstorm a list of local fish and wildlife resources
2. Select small groups to research different resources on the list.
3. Research local, traditional, and regulated methods of management.
4. Prepare a plan that maximizes the benefits and minimizes the negatives of managing the local fish or wildlife.
5. Present the plan to the class using visual aids.

Reflection and Revision

What is the best part of each plan? How can the plans be compiled into one, comprehensive plan?

Level of Performance

Stage 4 Student work is complete, is based on thorough research that includes in-depth interviews and multiple sources, and shows evidence of logical reasoning. Plan to manage local fish or wildlife is balanced and takes into consideration traditional stories and local history. Presentation is well organized, interesting, informative, and includes several visual aids

Stage 3 Student work is based on research that includes interviews and multiple sources and shows evidence of logical reasoning but may contain minor errors or omissions. Plan to manage local fish or wildlife is balanced and takes into consideration traditional stories and local history. Presentation is organized, interesting, informative, and includes at least one visual aid.

Stage 2 Student work is limited in scope and background information, may be incomplete or contain errors of science fact and reasoning. Presentation lacks organization and the visual aid, if present, is not used effectively or does not contain relevant information.

Stage 1 Student work is largely incomplete, incorrect, shows little evidence of understanding, contains misconceptions and plan is not based on research, tradition, or local history.

Standards Cross-References

National Science Education Standards

All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial. (Page 129)

Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply. (Page 134)

The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. (Page 134)

Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods. (Page 140)

A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem. (Page 157)

Benchmarks

Waves, wind, water, and ice shape and reshape the Earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers. (Page 72)

Rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains—and contains many living organisms. (Page 72)

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group. (Page 103)

For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all. (Page 116)

Insects and various other organisms depend on dead plant and animal material for food. (Page 116)

Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds. (Page 116)

Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. (Page 116)

Most microorganisms do not cause disease, and many are beneficial. (Page 116)

Level 3

Alaska Science Key Element A16

A student who meets the content standard should understand basic concepts about the Theory of Relativity, which changed the view of the universe by uniting matter and energy and by linking time with space (Relativity).

Performance Standard Level 3, Ages 11–14

Students describe how objects in one moving reference frame are perceived in reference to another moving reference frame (classical relativity)

Expanded Sample Assessment Idea

- Students examine relative motion and frames of reference

Procedure

Students will:

1. Imagine traveling on one snowmobile and your friend is on another; both vehicles are traveling at the same speed. (OR two boats on the river or ocean if this is more appropriate for the location and time of year.)
2. Describe how your friend appears to be traveling if his/her snowmobile is travelling in the opposite direction you; in the same direction alongside you; at an angle coming towards you.
3. Explain your answers using words and drawings.

Reflection and Revision

What evidence do you have in each of the above cases that the snowmobiles really are travelling at the same speed? Explain.

Would your answer to the last question be different if you were travelling in a "white out" condition (but could still just see the other snowmobile)? Why or why not?

Levels of Performance

Stage 4 — Student work is complete, correct and shows evidence of logical reasoning, extension and transfer of knowledge to new situations. The work includes drawings, explanations and the evidence used to support the conclusions made about the relative motion of the second vehicle under all three conditions and under "white out" environmental conditions.

Stage 3 — Student work shows evidence of logical reasoning, as well as some transfer of knowledge to new situations but may contain minor errors or omissions. The work includes drawings, explanations and the evidence used to support the conclusions made about the relative motion of the second vehicle under most conditions.

Stage 2 — Student work may show evidence of skilled artisanship, but may be incomplete or show evidence of errors and misconceptions about relative motion and frames of reference. Drawings and explanations may lack evidence and may incorrectly describe the motion of the second vehicle.

Stage 1 — Student work is mostly incomplete and shows evidence of major misconceptions regarding relative motion and frames of reference.

Standards Cross-References

National Science Education Standards

NA

Benchmarks

Many predictions from Einstein's Theory of Relativity have been confirmed on both atomic and astronomical scales. Still, the search continues for an even more powerful theory of the architecture of the universe. (Page 245)

Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous. (Page 269)

Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering. (Page 269)

Alaska Science Content Standard B

Level 3, Ages 11–14

A student should possess and understand the skills of scientific inquiry.

Alaska Science Key Element B1

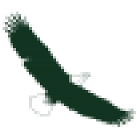
A student who meets the content standard should use the processes of science; these processes include observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

Performance Standard Level 3, Ages 11–14

Students hypothesize, make qualitative and quantitative observations, control experimental variables, interpret data; and use this information to explain everyday phenomena and make predictions.

Sample Assessment Ideas

- Students predict date of ice break-up on the river or ocean based on qualitative and quantitative observations of temperature, ice thickness, rate of run-off, and wind factors.
- Students identify the variables involved in local erosion, including water levels, wave action, nature of soil, wind, etc.



Expanded Sample Assessment Idea

- Students design several boats, using the same material, to test their own hypotheses about the relationship between mass, volume, and water displacement.

Procedure

Students will:

1. Design and build a boat that will move a 2 kg mass across a wading pool or large tub. Use a variety of materials.
2. Test the design. Review results and repeat with a design change.
3. Keep a daily log during the construction and testing. Include observations, measurements, predictions, data collection, and controlled variables.
4. Explain relationships of design differences and ability to hold increased mass.

Reflection and Revision

Compare boat designs with other groups and suggest changes to their boat designs.

Level of Performance

Stage 4 — Student work is correct, complete, and appropriate. It includes evidence-based hypothesis, accurate measurements and observations, control of all relevant variables, and uses data to design the second boat. Boat designs are creative and elaborate.

Stage 3 — Student work is generally correct, complete, and appropriate. It includes evidence-based hypothesis, accurate measurements and observations, control of all relevant variables, and uses data to design the boat. Boat designs are functional.

Stage 2 — Student's hypothesis is reasonable, some variables are controlled, measurements and observations are generally accurate, though there may be flaws. Boat designs show some use of the data collected.

Stage 1 — Student shows little or no ability to complete the task. The hypothesis is not relevant. Variables are not identified or controlled. Observations are mostly flawed. Boat designs are not functional.

Standards Cross-References

National Science Education Standards

Use appropriate tools and techniques to gather, analyze, and interpret data. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes (Page 145)

Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description-providing causes of effects and establishing relationships based on evidence and logical argument. This standard requires a subject-matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge. (Page 145)

Think critically and logically to make the relationships between evidence and explanations. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables. (Page 145)

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Use mathematics in all aspects of scientific inquiry. Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations. (Page 148)

Mathematics is important in all aspects of scientific inquiry. (Page 148)

Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations. (Page 148)

Benchmarks

If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations. (Page 12)

Level 3

Alaska Science Key Element B2

A student who meets the content standard should design and conduct scientific investigations using appropriate instruments.

Performance Standard Level 3, Ages 11–14

Students use appropriate instruments, develop and design a controlled experiment, and conduct research.

Sample Assessment Ideas

- Students predict which material is the best and worst conductor of electricity. Using a circuit board, students design and conduct an experiment to determine which material is the best and worst conductor.
- Students investigate the variables at work during cookie baking (e.g., thickness of dough, location in the oven, baking time, baking temperature). Students decide what observation and measurements are appropriate. Students record data and make conclusions based on experimental evidence.

Standards Cross-References

National Science Education Standards

Identify questions that can be answered through scientific investigations. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation. (Page 145)

Design and conduct a scientific investigation. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures. (Page 145)

Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models. (Page 148)

Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding. (Page 148)

Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations. (Page 148)

Benchmarks

Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence. (Page 12)

Be skeptical of arguments based on very small samples of data, biased samples, or samples for which there was no control sample. (Page 299)

Level 3

Alaska Science Key Element B3

A student who meets the content standard should understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

Performance Standard Level 3, Ages 11–14

Students compare their work to the work of others to identify multiple paths that can be used to investigate a particular question.

Sample Assessment Ideas

- Students investigate and collect data about the weather and soil; compare findings with teams from nearby communities; predict the best crops for different locations

Expanded Sample Assessment

- Students learn about the HIV virus, its biological nature, various cultural contexts, and how HIV is transmitted. Students develop multiple solutions to limit transmission of HIV and create lessons to teach another class about HIV.

Procedure

Students will:

1. Create a lesson they will present to another class that discusses the HIV virus, its effects, transmission, and how to potentially limit its spread in an infectious situation. The lesson should include the relative pros and cons of each method by which the infection could be limited.
2. Each group presents its lesson to the rest of the class.
3. Discuss and review each groups' presentation. Develop a lesson plan that contains some aspect of each group lesson.

Reflection and Revision

Evaluate the newly developed lesson plan in terms of completeness and depth of knowledge.

Level of Performance

Stage 4	Student work is complete, correct, and shows evidence of elaboration and extension. Student participates in class discussion and offers insightful examination of their work and the work of others.
Stage 3	Student work is generally complete and correct. Student participates in class discussion though there may be evidence of misconception in their own work or misunderstanding of the work of others.
Stage 2	Student work is on topic but lacks detail. Student may participate in class discussion in a limited way and show evidence of misconceptions and misunderstandings
Stage 1	Student participation in all aspects of activity is minimal and shows little or no evidence of relevant knowledge or understanding.

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen and to respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations. (Page 148)

Benchmarks

Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations. (Page 287)

Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct. (Page 287)

Be aware that there may be more than one good way to interpret a given set of findings. (Page 299)

Alaska Science Key Element B4

A student who meets the content standard should understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort, and logical reasoning are all aspects of scientific inquiry.

Performance Standard Level 3, Ages 11–14

Students design an experiment through a collaborative process, describing individual ways to answer the question before coming to group consensus on the best experimental design.

Sample Assessment Ideas

- Students set criteria by which to design, build and test various shelters that protect from the cold.
- Students develop an experiment to test the heat conductivity of wet and dry socks.

Standards Cross-References

National Science Education Standards

Think critically and logically to make the relationships between evidence and explanations. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables. (Page 145)

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. (Page 148)

Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (Page 170)

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (Page 171)

Benchmarks

Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct. (Page 287)

Alaska Science Key Element B5

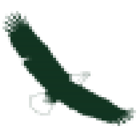
A student who meets the content standard should employ ethical standards, including unbiased data collection and factual reporting of results.

Performance Standard Level 3, Ages 11–14

Students practice factual recording of experimental results and unbiased data collection.

Sample Assessment Ideas

- Students collect data to determine whether eighth graders or seventh graders are better able to remember strings of random numbers. Discuss possible sources of bias in data interpretation. Discuss how bias influences the way the experiment was designed, conducted or interpreted.
- Students collect data on which lure is the best for Coho salmon. Discuss possible sources of bias in data interpretation. Discuss how bias influences the way the experiment was designed, conducted or interpreted.



Expanded Sample Assessment Idea

- Students measure the lung capacity of boys and girls.

Procedure

Students will:

1. Work in teams so that boys measure lung capacity of boys; boys measure lung capacity of girls; girls measure lung capacity of boys, and girls measure lung capacity of girls.
2. Measure individual lung capacity and determine the average lung capacity by sex. ("Bubbleology" texts are an excellent resource for this.)
3. Combine class data and discuss whether data collection was unbiased and factually reported. Discuss reasons for the four different types of teams.

Reflection and Revision

Recommend ways to ensure that data collection is unbiased and factually reported.

Level of Performance

Stage 4 — Student work is complete, correct and shows evidence of elaboration and extension. Student work includes methods to ensure unbiased data collection and factual reporting of data.

Stage 3 — Student work is generally complete and correct but shows limited evidence of elaboration and extension. Student work includes limited methods to address the challenges of unbiased data collection and factual reporting of data.

Stage 2 — Student work may be incomplete or incorrect and shows limited evidence of ability to address the challenges of unbiased data collection or factual reporting data.

Stage 1 — Student work is mostly incomplete and incorrect and may show evidence of biased data collection or non-factual reporting of data.

Standards Cross-References

National Science Education Standards

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. (Page 148)

Benchmarks

What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results. Scientists know about this danger to objectivity and take steps to try and avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same questions. (Page 12)

In research involving human subjects, the ethics of science require that potential subjects be fully informed about the risks and benefits associated with the research and of their right to refuse to participate. Science ethics also demand that scientists must not knowingly subject coworkers, students, the neighborhood, or the community to health or property risks without their prior knowledge and consent. Because animals cannot make informed choices, special care must be taken in using them in scientific research. (Page 17)

Know why it is important in science to keep honest, clear, and accurate records. (Page 287)

Question claims based on vague attributions (such as "Leading doctors say . . . ") or on statements made by celebrities or others outside the area of their particular expertise. (Page 299)

Be skeptical of arguments based on very small samples of data, biased samples, or samples for which there was no control sample. (Page 299)

Be aware that there may be more than one good way to interpret a given set of findings. (Page 299)

Notice and criticize the reasoning in arguments in which (1) fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, (2) an analogy is not apt, (3) no mention is made of whether the control groups are very much like the experimental group, or (4) all members of a group (such as teenagers or chemists) are implied to have nearly identical characteristics that differ from those of other groups. (Page 299)

Alaska Science Key Element B6

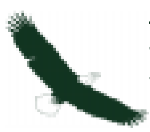
A student who meets the content standard should employ strict adherence to safety procedures in conducting scientific investigations

Performance Standard Level 3, Ages 11–14

Students examine laboratory and community safety procedures, identify how an individual affects the safety of the group, and practice safe behavior in the classroom and laboratory.

Sample Assessment Ideas

- Students in groups of three to five produce a short video of a mock experiment that lacks safety procedures. Videos are exchanged with another group who identifies the unsafe procedures and writes up the lab with the appropriate safety procedures included.
- Students produce a list of safety practices observed in a local industrial setting.



Expanded Sample Assessment Idea

- Students design safety procedures for a hypothetical gas station.

Procedure

Students will:

1. Review safe practices concerning toxic and volatile substances.
2. Draw up a plan detailing how gasoline will be unloaded, stored, and sold. The plan must include emergency response provisions for spills and accidents
3. Post their plan for class review and make recommendations to others' plans

Reflection and Revision

Incorporate safety improvements recommended by classmates and redraw the plan.

Level of Performance

Stage 4 — Student work is complete, correct, and shows evidence of elaboration, extension, higher-order thinking skills, and relevant knowledge. Students make appropriate revision to their own work and recommends appropriate changes to the work of others.

Stage 3 — Student work is generally complete though it may contain minor inaccuracies in the relevant knowledge. The work shows limited evidence of elaboration, extension or higher-order thinking skills. Students make some revision to their own work or recommend changes to the work of others.

Stage 2 — Student work is incomplete, inappropriate or incorrect. Revision to their own work or recommendation about the work of others, if included, is minor and insignificant.

Stage 1 — Student work may be on topic, but does not address the question of community safety in a meaningful way. Student does not revise work or review the work of others.

Standards Cross-References

National Science Education Standards

The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal and social dimensions. (Page 168)

Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks. (Page 169)

Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits. (Page 169)

Important personal and social decisions are made based on perceptions of benefits and risks. (Page 169)

Benchmarks

One common aspect of all social trade-offs pits personal benefit and the rights of the individual, on one side, against the social good and the rights of society, on the other. (Page 166)

Alaska Science Content Standard C

A student should understand the nature and history of science.

Alaska Science Key Element C1

A student who meets the content standard should know how the words “fact,” “observation,” “concept,” “principle,” “law,” and “theory” are generally used in the scientific community.

Performance Standard Level 3, Ages 11–14

Students will make and record observations and be able to link those observations to known scientific concepts, principles and laws.

Sample Assessment Ideas

- Students observe the mass and volume of a variety of objects are related to the density of the objects.
- Students observe the relationship between the length of the pendulum, length of its swing, the mass on its end, and the frequency of the pendulum swing.

Standards Cross-References

National Science Education Standards

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

Benchmarks

Know that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations. (Page 287)

Alaska Science
Key Element C2

A student who meets the content standard should understand that scientific knowledge is validated by repeated specific experiments that conclude in similar results

Performance Standard Level 3, Ages 11–14

Students conduct a series of experiments to demonstrate the reproducibility of scientific phenomena.

Sample Assessment Ideas

- Students chart the time the moon rises for two months; identify the pattern.
- Students research the decline of waterfowl in Alaska; identify which explanations are corroborated by similar data from other sites

Standards Cross-References

National Science Education Standards

Communicate scientific procedures and explanations. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond evidence, and suggesting alternative explanations for the same observations (Page 148)

Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods on procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations (Page 148)

Benchmarks

Know why it is important in science to keep honest, clear, and accurate records (Page 287)

When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it takes often further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct. (Page 7)

Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society. (Page 18)

Alaska Science Key Element C3

A student who meets the content standard should understand that society, culture, history, and environment affect the development of scientific knowledge

Performance Standard Level 3, Ages 11–14

Students describe how the local society, culture, history, and environment have affected the development of scientific knowledge.

Sample Assessment Ideas

- Students review epidemiological studies of different dietary practices (e.g., use of fats or salts, cholesterol intake); compare the data to local health issues
- Students investigate a current "hot topic" (e.g., game management, noise pollution and marine life, burn areas, seismic studies, endangered species, etc.); investigate the native oral histories related to the same topic.

Standards Cross-References

National Science Education Standards

Many different people in different cultures have made and continue to make contributions to science and technology. (Page 166)

Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis. (Page 166)

Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research. (Page 169)

Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research. (Page 169)

Science and technology have advanced through the contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies. (Page 169)

Women and men of various social and ethnic backgrounds, and with diverse interest, talents, qualities, and motivations, engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others (Page 170)

Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry science as a human endeavor, the nature of science, and the relationships between science and society. (Page 171)

In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples one finds that scientist and engineers of high achievement are considered to be among the most valued contributors to their culture. (Page 171)

Benchmarks

Some scientific knowledge is very old and yet still applicable today (Page 7)

Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times (Page 17)

No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world. (Page 17)

Level 3

Alaska Science Key Element C4

A student who meets the content standard should understand that some personal and societal beliefs accept non-scientific methods for validating knowledge.

Performance Standard Level 3, Ages 11–14

Students investigate the societal (non-scientific) belief of a community regarding a natural phenomenon.

Sample Assessment Ideas

- Students examine the traditional saying "If the fog goes up on a summer morning it will be cloudy all day. If the fog goes down, the sky will be clear all day." Why was this saying developed ? Collect traditional weather indicators through interviews with hunters, fishers, berry pickers, etc. Analyze and explain how these traditional indicators work.
- Students discuss different views of the origin of the universe, Earth, and life; discuss how the scientific view has changed over time

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others. (Page 169)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work toward finding evidence that will resolve their disagreement. (Page 171)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Some matters cannot be examined usefully in a scientific way. Among them are matters that by their nature cannot be tested objectively and those that are essentially matters of morality. Science can sometimes be used to inform ethical decisions by identifying the likely consequences of particular actions but cannot be used to establish that some action is either moral or immoral. (Page 7)

Level 3

Alaska Science Key Element C5

A student who meets the content standard should understand that sharing scientific discoveries is important to influencing individuals and society and in advancing scientific knowledge.

Performance Standard Level 3, Ages 11–14

Students work in a team to observe, research, and study an issue related to their community and synthesize data derived from multiple perspectives.

Sample Assessment Ideas

- Student teams test which ski wax works best under given conditions; compare results with other teams; compare results with ski was recommended by downhill skiers, Olympic skiers and dog sled users.
- Students do Internet research on the decline of marine mammal populations around the world and indicate which findings might be worth investigating to determine reasons for decline of stellar sea lions in the Bering Sea.

Expanded Sample Assessment Idea

- Students research local bear-human interactions to suggest ways to decrease the number of interactions and note the information they received from other communities or others' research.

Procedure

Students will:

1. Divide the class into groups representing particular viewpoints (game board, state and local agencies, Elders, parents, etc.).
2. Research libraries, Internet, oral histories, and documented human-bear conflicts and resolutions.
3. Using a forum format, discuss the issue from the viewpoints of the biologists, game board, parents, community members, kids, etc.
4. As a class, identify solutions that will minimize bear-human interactions, and that satisfy all of the involved groups.

Reflection and Revision

Compare solution to data collected and make modifications if necessary.

Level of Performance

Stage 4 — Student clearly communicates perspectives and makes use of others' perspectives to draw a conclusion. The response is correct, complete, appropriate, and contains elaboration, extension, and/or evidence of higher-order thinking and relevant knowledge. There is no evidence of misconceptions. Minor errors do not necessarily lower the score.

Stage 3 — Student communicates perspectives and makes some use of others' perspectives to draw a conclusion. Student work is generally correct, complete, and appropriate although minor inaccuracies are present. There may be limited evidence of elaboration, extension, higher-order thinking, and relevant knowledge, or there may be significant evidence of these traits, but other flaws (e.g. inaccuracies, omissions, inappropriateness) are evident.

Stage 2	Student communicates perspectives, but makes little use of others' perspectives to draw a conclusion. Student work, while it may contain some elements of proficient work, is inaccurate, incomplete, or inappropriate. There is little, if any, evidence of elaboration, extension, higher-order thinking, or relevant knowledge. There may be evidence of significant misconceptions.
Stage 1	Student attempts to communicate perspectives; however, there is little or no mention of the perspectives of others, nor any attempt to draw a conclusion. Student work, although it may be on topic, fails to address the question, or it may address the question in a very limited way. There is no evidence of elaboration, extension, higher-order thinking, or relevant knowledge. There is evidence of serious misconceptions.

Standards Cross-References

National Science Education Standards

Women and men of various social and ethnic backgrounds, and with diverse interests, talents, qualities, and motivations, engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others. (Page 170)

Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity as well as on scientific habits of the mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (Page 170)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work toward finding evidence that will resolve their disagreement. (Page 171)

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (Page 171)

Benchmarks

Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times. (Page 17)

No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world. (Page 17)

Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society. (Page 18)

Alaska Science Key Element C6

A student who meets the content standard should understand that scientific discovery is often a combination of an accidental happening and observation by a knowledgeable person with an open mind.

Performance Standard Level 3, Ages 11–14

Students describe the steps in the development of a widely used technology (e.g., Teflon©, sticky notes, nylon, penicillin, etc.)

Sample Assessment Ideas

- Students research a serendipitous discovery (e.g., Teflon©, sticky notes, nylon, penicillin, Jello, etc.); write a report or create a diagram describing the discovery.
- Students discuss "new ideas" that eventually overcame skepticism (e.g., plate tectonics, existence of viruses, atoms and molecules).

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and predictions. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (Page 148)

Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond evidence, and suggesting alternative explanations for the same observations (Page 148)

Benchmarks

Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way. (Page 7)

Level 3

Alaska Science Key Element C7

A student who meets the content standard should understand that major scientific breakthroughs may link large amounts of knowledge, build upon the contributions of many scientists, and cross different lines of study.

Performance Standard Level 3, Ages 11–14

Students design concept webs that show how contributions across a variety of fields are used to produce inventions.

Sample Assessment Ideas

- Students research and write a short report tracing the history of a scientific concept or invention (e.g., atomic theory, telephone).
- Students discuss the scientific contributions from a variety of fields necessary to develop technology (e.g., Global Positioning System, Alaska Pipeline, Space Shuttle).

Standards Cross-References

National Science Education Standards

Many different people in different cultures have made and continue to make contributions to science and technology. (Page 166)

Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies. (Page 169)

Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies. (Page 169)

Women and men of various social and ethnic backgrounds-and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others (Page 170)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times. (Page 17)

Alaska Science Key Element C8

A student who meets the content standard should understand that acceptance of a new idea depends upon supporting evidence and that new ideas that conflict with belief or common sense are often resisted.

Performance Standard Level 3, Ages 11–14

Students show how acceptance of a new idea depends upon supporting evidence and how new ideas that conflict with belief or common sense are often resisted.

Sample Assessment Ideas

- Students investigate what happens when a large variety of unopened cans of soft drinks (different brands, diet vs. non-diet, carbonated vs non-carbonated, clear vs colored, etc.) are placed in a large bucket of water.
- Students predict and test if the speed of emptying a bottle can be changed by holding it stationary, shaking it up and down while emptying, or by swirling it as it empties.

Standards Cross-References

National Science Education Standards

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations. (Page 171)

In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement. (Page 171)

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists might disagree about explanations of phenomena, about interpretation of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the scientific process. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (Page 171)

Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted. (Page 171)

Benchmarks

Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way. (Page 7)

Some scientific knowledge is very old and yet is still applicable today. (Page 7)

Alaska Science Content Standard D

Level 3, Ages 11–14

A student should be able to apply scientific knowledge and skills to make reasoned decisions about the use of science and scientific innovations.

Alaska Science Key Element D1

A student who meets the content standard should apply scientific knowledge and skills to understand issues and everyday events.

Performance Standard Level 3, Ages 11–14

Students research a local problem or issue and form a viewpoint that is supported by scientific evidence.

Sample Assessment Ideas

- Students discuss a problem such as possible causes and effects of muddy or dusty hiking trails and suggest a solution that is feasible for the community to implement.
- Students research spruce bark beetles in their local area and assess their economic, ecological, and aesthetic impact.

Standards Cross-References

National Science Education Standards

Develop descriptions, explanations, predictions, and models using evidence. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description-providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge. (Page 145)

Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. (Page 148)

Benchmarks

Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence. (Page 12)

Level 3

Alaska Science Key Element D2

A student who meets the content standard should understand that scientific innovations may affect our economy, safety, environment, health, and society and that these effects may be short-term or long-term, positive or negative, and expected or unexpected.

Performance Standard Level 3, Ages 11–14

Students describe the unexpected effects, both positive and negative and short- and long-term, of a discovery, invention, or scientific breakthrough.

Sample Assessment Ideas

- Students examine the effect of snow tire restrictions (or removing the restrictions) on the state and local economy, and the safety and health of Alaskans.
- Students examine and report on how technology has affected them locally (e.g., northern cold-climate adapted seeds, new monofilament fishing net, Global Positioning System for hunting).

Standards Cross-References

National Science Education Standards

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side-effects; and technologies cost, carry risks, and provide benefits. (Page 166)

Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot. (Page 166)

Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development. (Page 169)

Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies. (Page 169)

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others. (Page 169)

Benchmarks

Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. But they usually have to take human values and limitations into account as well. (Page 46)

New technologies increase some risks and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks. (Page 56)

Alaska Science Key Element D3

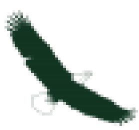
A student who meets the content standard should recommend solutions to everyday problems by applying scientific knowledge and skills

Performance Standard Level 3, Ages 11–14

Students identify a community problem or issue, collect information and secondary research, and propose a scientific solution.

Sample Assessment Ideas

- Students research modern and traditional methods of storing food and design a plan that will allow them to preserve food during a one-week power outage.
- Students discuss the impact of newly constructed roads in their area; identify benefits, problems, and solutions.



Expanded Sample Assessment Idea

- Students research local flooding and erosion in their community and make recommendations to better safeguard the community.

Procedure

Students will:

1. Meet with local populace affected by flooding or erosion.
2. Collect data and simulate a public meeting to share the benefits, problems, and concerns.
3. Break into community "groups" and select a problem to investigate (one that has a scientific solution).
4. Share their recommendations with other groups in another public meeting.
5. Revise their solution based on feedback from the public meeting.

Reflections and Revisions

Visit other sites and determine whether more than one site could benefit from the same solution.

Level of Performance

Stage 4 — Student work is complete and contains evidence of elaboration, extension, higher-order thinking skills, and relevant knowledge. Student actively participates in meeting with local populace and helps identify community area most affected by flooding or erosion; and actively participates in student group to investigate the problem area, collect data and make recommendations based on the data. Student identifies a second site affected by same problem and determines if this site could benefit from the same solution.

Stage 3 — Student work is complete but may contain some evidence of inaccuracies, omissions or misconceptions. Student participates in meeting with local populace as they identify community area most affected by flooding or erosion. Student participates in student group to study the problem area and make recommendations based on their observations. Student may identify a second site affected by the same or similar problem and determine if this site could benefit from the same solution.

Stage 2 Student work may be incomplete, incorrect, or inaccurate. Student attends meeting with local populace and works with student group to visit the problem area. Recommendations may be based solely on personal experience or non-science factors (e.g., economics, aesthetics, etc.) Student may identify a second site that is unrelated to the first site

Stage 1 Student work is incomplete, inaccurate, and lacking in relevant details. Student does not attend meeting with local populace or attends the meeting but does not follow along with the discussion to identify a problem area. Student is a reluctant group participant and does not make recommendations for the problem area.

Standards Cross-References

National Science Education Standards

Identify appropriate problems for technological design. Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product. (Page 165)

Design a solution or product. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints such as cost, time, trade-offs, and materials needed and communicate ideas with drawings and simple models. (Page 165)

Benchmarks

Design usually requires taking constraints into account. Some constraints, such as gravity or the properties of the materials to be used are unavoidable. Other constraints, including economic, political, social, ethical, and aesthetic ones, limit choices. (Page 51)

Level 3

Alaska Science Key Element D4

A student who meets the content standard should evaluate the scientific and social merits of solutions to everyday problems

Performance Standard Level 3, Ages 11–14

Students evaluate the scientific and societal impact of recent technologies

Sample Assessment Ideas

- Students research different types of tires and tracks left by different vehicles (e.g., bicycles, automobiles, ATVs, tractors, heavy construction equipment, and snow machines); identify patterns; draw conclusions
- Students evaluate the societal and scientific impact of telecommunications (e.g., cell phones, the Internet, television, satellite dishes, telephone, etc.) in their community.

Expanded Sample Assessment Mini-Unit: HIV

- Students create a class presentation that discusses the HIV virus, its effects, transmission, a method to limit its spread; evaluate societal impact of the proposed method.

Procedure

Students will:

1. Create a lesson to present to another class that discusses the HIV virus, its effects, transmission, and how to potentially limit its spread in an infectious situation (being very clear as to the relative pros and cons of each of the methods to restrict the spread of infection).
2. Present the lesson to a different class. Following the presentation, each person in that class will receive a labeled cup containing 50 ml of a liquid (all of the cups contain plain water except for two which contain an additional 2 ml of 0.1M sodium hydroxide). The class is instructed that each student must complete four exchanges of liquid. Student presenters collect the cups, test for the presence of sodium hydroxide using an acid-base indicator, analyze the results, and report back to the class
3. Discuss and review each groups' presentation in light of their sample results
4. Discuss and review each groups' presentation with regard to societal impact.

Level of Performance

Stage 4 — Student report includes a thorough investigation of the effects of the HIV virus, its transmission, and the methods to limit its spread. The report is detailed, extensive, and includes evidence of clear and logical reasoning

Stage 3 — Student report includes a thorough investigation of the effects of the HIV virus, its transmission, and the methods to limit its spread, although equal importance may not be placed on all three aspects. The report is detailed and includes evidence of clear and logical reasoning. Minor errors do not affect the results

Stage 2 — Student report shows limited evidence of investigation of the HIV virus, its transmission, and methods to limit its spread. Student work is incomplete and may contain errors of scientific fact or reasoning.

Stage 1 — Student report shows little or no evidence of investigation of the HIV virus, its transmission, and methods to limit its spread. The report is largely incomplete, incorrect, or contains evidence of misconceptions related to scientific reasoning.

Mini-Unit: HIV

Performance Standard D4, Level 3

Students evaluate the scientific and societal impact of recent technologies.

Key Concepts and Skills

- Scientific methods are used to evaluate the effectiveness of problem solving.
- Transmission method of HIV in specific ways
- Recent technology has affected society.

Timeline

3 weeks

Abstract

Students will learn about the HIV virus (its biological nature and various cultural contexts). Through a class experiment, students will explore how HIV is transmitted and, as a result of discussion and experimentation, develop multiple solutions to limit its transmission. Students will then create lessons that they will teach to another class about HIV, what it is, how it is transmitted, and how its transmission can be limited.

Materials

- ✔ Clear plastic cups
- ✔ Internet access
- ✔ Phenolphthalein
- ✔ Research materials
- ✔ Sodium hydroxide
- ✔ Paper
- ✔ Water
- ✔ Science journal

Alaska Science Content Standard Key Element

A student who meets the content standard should understand that similar features are passed on by genes through reproduction.

Cross-Reference

Activities

1

Each student receives a plastic cup with 50 ml of water. However, two cups also have 2 ml of 0.1M sodium hydroxide solution as well. Designate two students to act as observers (to watch who was exchanging with whom—and noting behavior of the students during the exchanges). On command, each student needs to pour the contents of his or her cup into another students' cup, and then receive back half of the liquid. Repeat this two more times with other students. Teacher describes that two cups were initially affected and that the class needs to determine which cups were initially affected. Teacher then goes to each students' cup and adds the phenolphthalein indicator. A class discussion occurs during this process regarding the possible sources for the infection.

2

Discussions and lessons occur regarding the biology of the HIV virus, the mathematics of infection, the effects of drugs and alcohol on transmission rates, refusal skills, hygiene, medical treatments, and location. During the discussions Students will create a list of possible ways to control the spread of the infection.

3

Discussions and lessons occur regarding societal impact of recent technology advances. Discussion should focus on health policies regarding disease and safety (for example, seat belts, vaccinations).

4

Students will devise (based upon the idea presented in the first activity) one or more experiments that test out their possible solutions to limiting the spread of the infection.

Expanded Sample Assessment

Students create a class presentation that discusses the HIV virus, its effects, transmission, a method to limit its spread, and then evaluate societal impact of the proposed method.

Procedure

Students will:

1. Create a lesson to present to another class that discusses the HIV virus, its effects, transmission, and how to potentially limit its spread in an infectious situation (being very clear as to the relative pros and cons of each of the methods to restrict the spread of infection).
2. Present the lesson to a different class. Following the presentation, each person in that class will receive a labeled cup containing 50 ml of a liquid (all of the cups contain plain water except for two which contain an additional 2 ml of 0.1M sodium hydroxide). The class is instructed that each student must complete four exchanges of liquid. Student presenters collect the cups, test for the presence of sodium hydroxide using an acid-base indicator, analyze the results, and report back to the class

3. Discuss and review each group's presentation in light of their sample results
4. Discuss and review each group's presentation with regard to societal impact.

Level of Performance

Stage 4 — Student report includes a thorough investigation of the effects of the HIV virus, its transmission, and the methods to limit its spread. The report is detailed, extensive, and includes evidence of clear and logical reasoning.

Stage 3 — Student report includes a thorough investigation of the effects of the HIV virus, its transmission, and the methods to limit its spread, although equally importance may not b placed on all three aspects. The report is detailed and includes evidence of clear and logical reasoning. Minor errors do not affect the results

Stage 2 — Student report shows limited evidence of investigation of the HIV virus, its transmission, and methods to limit its spread. Student work is incomplete and may contain errors of scientific fact or reasoning.

Stage 1 — Student report shows little or no evidence of investigation of the HIV virus, its transmission, and methods to limit its spread. The report is largely incomplete, incorrect, or contains evidence of misconceptions related to scientific reasoning.

Standards Cross-References

National Science Education Standards

Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risk, and provide benefits (Page 166)

Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology. (Page 166)

Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot. (Page 166)

Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental. (Page 169)

Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development. (Page 169)

Benchmarks

New technologies increase some risk and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks. (Page 56)

Alaska Science Key Element D5

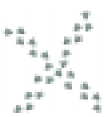
A student who meets the content standard should participate in reasoned discussions of public policy related to scientific innovation and proposed technological solutions to problems.

Performance Standard Level 3, Ages 11–14

Students describe how public policy affects their lives and participate diplomatically in evidence-based discussions relating to their community.

Sample Assessment Idea

- Students choose an issue from their community (e.g., aerial wolf hunting, fishing in national parks, air boats, failure to adopt recycling, subsistence fishing, goose over-population, etc.), choose a policy position, and using evidence present arguments for their position.
- Students choose a school policy (e.g., Internet access, teacher-student ratios) and provide both positive and negative effects on the school population.



Standards Cross-References

National Science Education Standards

The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions. (Page 168)

Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes. (Page 168)

Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental. (Page 169)

Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research. (Page 169)

Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development. (Page 169)

Benchmarks

The human ability to shape the future comes from a capacity for generating knowledge and developing new technologies—and for communicating ideas to others. (Page 55)

Technology cannot always provide successful solutions for problems or fulfill every human need. (Page 55)

New technologies increase some risks and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks. (Page 56)

Rarely are technology issues simple and one-sided. Relevant facts alone, even when known and available, usually do not settle matters entirely in favor of one side or another. That is because the contending groups may have different values and priorities. They may stand to gain or lose in different degrees, or may make very different predictions about what the future consequences of the proposed action will be. (Page 56)

Societies influence what aspects of technology are developed and how these are used. People control technology (as well as science) and are responsible for its effects. (Page 56)

Level 3

Alaska Science Key Element D6

A student who meets the content standard should act upon reasoned decisions and evaluate the effectiveness of the action.

Performance Standard Level 3, Ages 11–14

Students use scientific reasoning to design a solution to a problem or issue and evaluate the effectiveness of the solution.

Sample Assessment Ideas

- Students test the effectiveness of various food storage methods; test their designs; analyze the effectiveness of each method.
- Students examine permafrost, the effects of the removal of tundra, types of foundations used in villages, and which homes need more frequent leveling, and determine the best foundation for a house built on permafrost. A booklet will be printed on recommendations of future foundation construction.

Standards Cross-References

National Science Education Standards

Design a solution or product. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints—such as cost, time, trade-offs, and materials needed—and communicate ideas with drawings and simple models. (Page 165)

Implement a proposed solution. Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy. (Page 165)

Evaluate completed technological designs or products. Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications. (Page 165)

Communicate the process of technological design. Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation. (Page 166)

Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others. (Page 169)

Benchmarks

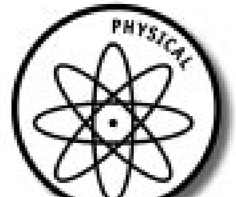
Technology cannot always provide successful solutions for problems or fulfill every human need. (Page 55)

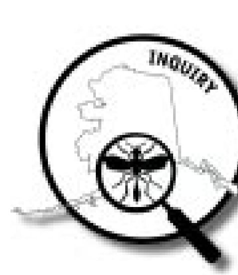
Societies influence what aspects of technology are developed and how these are used. People control technology (as well as science) and are responsible for its effects. (Page 56)

Translating Standards to Practice

A Teacher's Guide to Use and Assessment of the Alaska Science Standards

LEVEL 4, Ages 15–18





Alaska Science Content Standard A

Level 1, Ages 15–18

A student should understand scientific facts, concepts, principles, and theories.

Level 4

Alaska Science Key Element A1

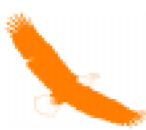
A student who meets the content standard should understand models describing the nature of molecules, atoms, and sub-atomic particles and the relation of the models to the structure and behavior of matter.

Performance Standard Level 4, Ages 15–18

Students develop, create and use models to demonstrate their understanding of the nature of particles and their interactions on the molecular, atomic and subatomic levels, and how these explain the physical and chemical properties of matter.

Sample Assessment Ideas

- Students experiment with puffed rice and a Van DeGraaf static electricity generator OR an "electric ferry" apparatus (styrofoam, tin cans, pencil, string, tack, electron source); build models to explain the observations using subatomic, atomic, molecular, and particulate structures
- Students compare the viscosity of different oils, greases, petroleum and synthetic lubricants at different temperatures; build models to explain differences in properties.



Expanded Sample Assessment Idea

- Students examine samples of salt (NaCl) crystals and sugar crystals; prepare solutions and measure conductivity and freezing points; build models that exhibit differences at the subatomic, atomic and molecular level of organization and account for the differences in observations. **[Proper SAFETY precautions should be used.]**

Procedure

Students will:

1. Use a magnifying glass or microscope and hardness test device (e.g. scratch block) to observe and describe properties of salt and sugar crystals.
2. Prepare quantitative solutions of at least two different concentrations of salt in water (e.g. 0.1g per 100g water, and 2 g per 100 g water) and attempt to do the same using hexane instead of water.
3. Prepare quantitative solutions of at least two different concentrations of sugar in water (e.g. 0.1g per 100g water, and 2 g per 100 g water) and attempt to do the same using hexane instead of water.
4. Observe and compare the properties of the solutions using simple conductivity apparatus.
5. Observe and compare the freezing point of each solution and the freezing point of pure water and pure hexane.
6. Build models to represent the two different solids and the different solutions; models should include differences at the subatomic level (i.e. electrons and nucleus), atomic level (i.e. ions vs. covalent bonds) and the molecular level (i.e. polar vs. non-polar solvents).
7. Use the models to explain orally (or in writing) the difference between a solid and a solution.

Reflection and Revision

Use the models to explain how differences between the solid and their solutions leads to the observed differences in properties. Why do some solids dissolve in some liquids and not in others?

Stage 4 — Student work is complete, correct and shows evidence of logical reasoning and detailed evidence of extension and transfer of knowledge related to particle interactions. Models accurately represent both crystalline and solution structures in terms of the subatomic, atomic and molecular components. The models are used to explain most of the observed differences between ionic and covalent molecules (dissolving, solubility, conductivity and changes in freezing points).

Stage 3 — Student work shows evidence of logical reasoning and some evidence of extension or transfer of knowledge related to particle interactions. Models represent crystalline and solution structure in terms of the subatomic, atomic and molecular components though minor errors or omissions may be present. The models are used to explain some of the observed differences between ionic and covalent molecules (dissolving, solubility, conductivity, or changes in freezing points).

Stage 2 — Student work may show evidence of skilled craftsmanship but shows limited evidence of knowledge related to particle interactions or subatomic, atomic, and molecular structures. Models represent crystalline or solution structures and are used to explain at least one of the observed differences between ionic and covalent molecules (dissolving, solubility, conductivity or changes in freezing points).

Stage 1 — Student work is mostly incomplete, incorrect and shows little or no evidence of knowledge related to particle interactions.

Standards Cross-References

National Science Education Standards

Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atoms together. (Page 178)

The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element. (Page 178)

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. (Page 178)

Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes. (Page 178)

Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element. (Page 178)

An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies. (Page 178)

Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically. (Page 179)

The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them. (Page 179)

Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid;

in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart. (Page 179)

Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life. (Page 179)

Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance. (Page 180)

Benchmarks

The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. But a close match does not necessarily mean that the model is the only "true" model or the only one that would work. (Page 270)

A physical or mathematical model can be used to estimate the probability of real-world events. (Page 230)

Atoms are made of a positive nucleus surrounded by negative electrons. An atom's electron configuration, particularly the outermost electrons, determines how the atom can interact with other atoms. Atoms form bonds to other atoms by transferring or sharing electrons. (Page 80)

The nucleus, a tiny fraction of the volume of an atom, is composed of protons and neutrons, each almost two thousand times heavier than an electron. The number of positive protons in the nucleus determines what an atom's electron configuration can be and so defines the element. In a neutral atom, the number of electrons equals the number of protons. But an atom may acquire an unbalanced charge by gaining or losing electrons. (Page 80)

Neutrons have a mass that is nearly identical to that of protons, but neutrons have no electric charge. Although neutrons have little effect on how an atom interacts with others, they do affect the mass and stability of the nucleus. Isotopes of the same element have the same number of protons (and therefore electrons) but differ in the number of neutrons. (Page 80)

Scientists continue to investigate atoms and have discovered even smaller constituents of which electrons, neutrons, and protons are made. (Page 80)

When elements are listed in order by the masses of their atoms, the same sequence of properties appears over and over again in the list. (Page 80)

Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules. (Page 80)

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others. (Page 80)

Level 4

Alaska Science Key Element A2

A student who meets the content standard should understand the physical, chemical, and nuclear changes and interactions that result in observable changes in the properties of matter (Changes and Interactions of Matter).

Performance Standard Level 4, Ages 15–18

Students describe and explain a common chemical reaction including atomic structure, chemical bonding and reaction rates.

Sample Assessment Ideas

- Students burn (or attempt to burn) four different substances; make qualitative and quantitative evaluations before and after combustion; state what has happened in each combustion attempt.
- Students use metals and non-metals in a reaction with hydrochloric acid; make qualitative and quantitative evaluations before and after the reactions; use chemical symbols and models to describe each chemical reaction.

Expanded Sample Assessment Idea

- Students build a bottle "firework" using hydrochloric acid and calcium carbonate; explain the complete reaction; relate the chemical reaction to the production of cave formations. **[Proper SAFETY should be used.]**

Materials

- ✔ 1 or 2 liter plastic bottle
- ✔ rubber stopper to fit
- ✔ streamers to tape to stopper
- ✔ calcium carbonate
- ✔ hydrochloric acid OR vinegar (vinegar can be used but it gives the students a more difficult equation)
- ✔ balance
- ✔ graduated cylinder
- ✔ paper towels

Procedure

Students will:

1. Measure a given mass (about 1 gram) of calcium carbonate; place in a paper twist.
2. Measure 5–10 mL of 0.1M hydrochloric acid into a bottle.
3. Place the paper twist of carbonate in the bottle and rapidly cork the bottle.
4. Shake to mix the chemicals; **DO NOT POINT** at anyone.
5. Make complete lab records in a journal about what was observed and what happens.
6. Write equations to explain what is observed.

Reflection and Revision

How does this activity relate to the formation of stalactites and stalagmites in caves? To the weathering of marble statues in industrial cities? Instead of popping the cork, design a way to test the gas that is produced and prove its identity; get approval of the design; carry out the tests; interpret the results in a journal.

Levels of Performance

Stage 4 — Student work shows clear understanding of matter rearrangements that take place in chemical reactions. Balanced equations are written for all reactions. Observations are thorough and interpreted in considerable detail using logical reasoning.

Stage 3 Student work shows understanding of matter rearrangements that take place in chemical reactions. Balanced equations are written for most reactions. Observations are thorough and interpreted with some evidence of logical reasoning although minor errors may be present.

Stage 2 Student work shows limited understanding of matter rearrangements that take place in chemical reactions. Equations are attempted but they are not balanced or they contain errors. Observations are minimal, contain errors or are interpreted with limited evidence of logical reasoning.

Stage 1 Student work shows little understanding of matter rearrangements that take place in chemical reactions. Equations, if present, are highly flawed. Observations are minimal or totally incorrect, and observations, if present, contain major misconceptions.

Standards Cross-References

National Science Education Standards

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. (Page 178)

Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes. (Page 178)

Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element. (Page 178)

Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically. (Page 179)

The physical properties of compounds reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them. (Page 179)

Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life. (Page 179)

Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies. (Page 179)

Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog. (Page 179)

A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions. (Page 179)

Chemical reactions can take place in time periods ranging from the few femtoseconds (10^{-15} seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties—including shape—of the reacting species. (Page 179)

Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes. (Page 179)

Benchmarks

The nucleus of radioactive isotopes is unstable and spontaneously decays, emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate. This predictability of decay rate allows radioactivity to be used for estimating the age of materials that contain radioactive substances. (Page 80)

Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules. (Page 80)

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others. (Page 80)

The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others. (Page 80)

Level 4

Alaska Science Key Element A3

A student who meets the content standard should understand models describing the composition, age, and size of our universe, galaxy, and solar system and understand that the universe is constantly moving and changing (Universe).

Performance Standard Level 4, Ages 15–18

Students use secondary research to develop models that explain the origin and continued development of the solar system, galaxy, and the universe.

Sample Assessment Ideas

- Students make a model of the sun-Earth-lunar system that is accurately scaled for both size and distance.
- Students conceptually demonstrate the “Big Bang”, including the center of expansion and continued thinning of mass per volume by inflating a balloon covered with dots from a marking pen.

Expanded Sample Assessment Ideas

- Students model star movement and explain the red shift.

Procedure

Students will:

1. Break into groups of four, each contributing specific information to the activity.
2. Use the Internet to collect information about star movement.
3. Demonstrate the Doppler effect by moving a sound source of constant pitch towards the listener and away from the listener.
4. Discuss how to use the Doppler effect to describe the relative motion of stars.
5. Make a model or draw a picture and use it to demonstrate how a change in motion and position causes a change in wave frequency.
6. Discuss the red-shift of light.

Reflection and Revision

Compare and contrast light energy and sound energy. What other energy sources are emitted from stars in addition to light energy? How is the energy source used to identify the type of star? The distance of the star? What evidence is used to identify the chemical composition of a star? What evidence is used to identify the age of a galaxy? Use your model to explain the motion and movement of blue-shifted stars and galaxies.

Level of Performance

Stage 4 Student explanation is complete and shows evidence of logical reasoning. The model or drawing accurately describes how a change in motion and position causes a change in wave frequency. The student uses the model or drawing to explain blue-shift and the movement of blue-shifted galaxies. The student explanation contains detailed evidence of how energy-related information is used to classify, identify, and describe stars or galaxies in the universe.

Stage 3 Student explanation shows evidence of clear and logical reasoning, but may contain minor errors or omissions. The model or drawing describes how a change in motion and position causes a change in wave frequency. Minor errors or omissions may be present. The student uses the model or drawing to explain blue-shift or the movement of blue-shifted galaxies. The student explanation contains some evidence of how energy-related information is used to classify, identify, or describe stars or galaxies in the universe.

Stage 2 — The model or drawing may contain evidence of skilled craftsmanship but may be incomplete, incorrect, or lack detail. Student explanation contains limited knowledge of how to classify, identify, or describe stars or galaxies in the universe. It may contain errors of science fact and reasoning.

Stage 1 — The model, drawing, and student explanation are largely incomplete and incorrect.

Standards Cross-References

National Science Education Standards

The sun, the Earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago. The early Earth was very different from the planet we live on today. (Page 189)

The origin of the universe remains one of the greatest questions in science. The "Big Bang" theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since. (Page 190)

Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe. (Page 190)

Benchmarks

The stars differ from each other in size, temperature, and age, but they appear to be made up of the same elements that are found on the Earth and to behave according to the same physical principles. Unlike the sun, most stars are in systems of two or more stars orbiting around one another. (Page 65)

On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass. Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. Eventually, some stars exploded, producing clouds of heavy elements from which other stars and planets could later condense. The process of star formation and destruction continues. (Page 65)

Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. (Page 65)

Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe. (Page 65)

Level 4

Alaska Science Key Element A4

A student who meets the content standard should understand observable natural events such as tides, weather, seasons, and moon phases in terms of the structure and motion of the Earth (Earth).

Performance Standard Level 4, Ages 15–18

Students explain tides, weather, seasons, and phases of the moon including the appropriate concepts of gravity, the Coriolis effect, role of the atmosphere, and Earth's rotation and revolution.

Sample Assessment Ideas

- Students research how air and water regions of different temperature and density move to drive circulation patterns and large-scale weather patterns.
- Students debate the scientific evidence for and against global warming.

Standards Cross-References

National Science Education Standards

Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents (Page 189)

Global climate is determined by energy transfer from the sun at and near the Earth's surface. This energy transfer is influenced by dynamic processes such as cloud cover and the Earth's rotation, and static conditions such as the position of mountain ranges and oceans (Page 189)

Benchmarks

Life is adapted to conditions on the Earth, including the force of gravity that enables the planet to retain an adequate atmosphere, and an intensity of radiation from the sun that allows water to cycle between liquid and vapor (Page 70)

Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans, and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall and such circulation, influenced by the rotation of the Earth, produces winds and ocean currents (Page 70)

Level 4

Alaska Science Key Element A5

A student who meets the content standard should understand the strength and effects of the forces of nature, including gravity and electromagnetic radiation (Forces of Nature).

Performance Standard Level 4, Ages 15–18

Students explain how gravity and electromagnetic forces operate according to simple principles and how they can be used in applications such as mineral resource prospecting, satellites, space travel and to affect natural phenomena such as the aurora.

Sample Assessment Ideas

- Students explain how microwaves, radio waves, and x-rays are related and identify technologies which utilize them in everyday applications.
- Students use observations on the Internet or collect data related to sunspot activity, the occurrence of electromagnetic disturbances on Earth, aurora displays, NASA precautionary plans, and communications blackouts; create a report that explains how electromagnetism affects life on Earth.

Standards Cross-References

National Science Education Standards

Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them. (Page 180)

The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them. (Page 180)

Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces such as those exerted by a coiled spring or friction may be traced to electric forces acting between atoms and molecules. (Page 180)

Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators. (Page 180)

Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength. (Page 180)

In some materials, such as metals, electrons flow easily whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons. (Page 181)

Benchmarks

Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x-rays and gamma rays. These wavelengths vary from radio waves, the longest, to gamma waves, the shortest. In empty space, all electromagnetic waves move at the same speed—the "speed of light." (Page 92)

Gravitational force is an attraction between masses. The strength of the force is proportional to the masses and weakens rapidly with increasing distance between them. (Page 96)

Electromagnetic forces acting within and between atoms are vastly stronger than the gravitational forces acting between the atoms. At the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus are involved in all chemical reactions. On a larger scale, these forces hold solid and liquid materials together and act between objects when they are in contact—as in sticking or sliding friction. (Page 96)

There are two kinds or charges—positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral. Negative charges, being associated with electrons, are far more mobile in materials than positive charges are. A very small excess of negative charges in a material produces noticeable electric forces. (Page 96)

Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily whereas in insulating materials such as glass, they can move hardly at all. At very low temperatures, some materials become superconductors and offer no resistance to the flow of current. In between these extremes, semiconducting materials differ greatly in how well they conduct, depending on their exact composition. (Page 97)

Magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force. Moving electric charges produce magnetic forces and moving magnets produce electric forces. The interplay of electric and magnetic forces is the basis for electric motors, generators, and many other modern technologies, including the production of electromagnetic waves. (Page 97)

The forces that hold the nucleus of an atom together are much stronger than the electromagnetic force. That is why such great amounts of energy are released from the nuclear reactions in the sun and other stars. (Page 97)

Level 4

Alaska Science Key Element A6

A student who meets the content standard should understand that forces of nature cause different types of motion, and describe the relationship between these forces and motion (Motion).

Performance Standard Level 4, Ages 15–18

Students explain common examples of linear and rotational motion using Newton's Laws of Motion.

Sample Assessment Ideas

- Students calculate speed and position as a function of time for a boat traveling both upstream and downstream in a known current if the motor force of the boat is known.
- Students describe and calculate the orbital velocity of a geostationary satellite at a fixed height above Earth.

Expanded Sample Assessment Idea

- Students experiment with sleds to determine acceleration due to a constant force.

Procedure

Students will:

1. Mark off 5m increments along a track; use a spring scale between the sled and a pulling force to assure constant force; tow a sled or skateboard on a hard or ice surface (e.g. lake, well-packed snow machine track, ice rink.)
2. Measure time between marks.
3. Calculate velocity.
4. Graph velocity vs time and determine acceleration; graph acceleration vs time.
5. Vary the weight on the slide, surface type, force; repeat calculations and graphing steps

Reflection and Revision

Write a formal lab report that includes:

- ✔ **Materials & Methods** (include calculations and graphs)
- ✔ **Data Analysis** (include sources of experimental error due to the sled, the snow type, human error; methods to reduce experimental error; description of the forces acting on the sled when it is stationary, when it is moving)
- ✔ **Data Interpretation** (include a description of the experimental results using Newton's Laws of Motion and coefficient of friction)
- ✔ **Applications** (include a discussion of Newton's three laws at work in a related local activity such as driving a vehicle, playing sports, hunting, and so on)

Levels of Performance

Stage 4 Student work is complete, correct and shows detailed evidence of the transfer and extension of knowledge that relates forces to motion. Each section of the lab report is detailed and shows evidence of logical reasoning. Calculations are accurate; graphs are correctly labeled and accurately represent the observations; error analysis contains detailed discussion of each source of error; experimental results are interpreted according to Newton's Laws of Motion as well as coefficient of friction and the Applications section includes a thorough discussion of how Newton's Laws of Motion apply to daily living or a local activity.

Stage 3 — Student work is mostly complete and shows evidence of the transfer or extension of knowledge that relates forces and motion. Most sections of the lab report shows evidence of logical reasoning, although some sections may contain minor errors or omissions. Calculations are mostly accurate; graphs are labeled and represent the observations; error analysis contains a discussion of sources of error; experimental results are interpreted according to Newton's Laws of Motion or coefficient of friction; and the applications section includes a discussion of how Newton's Laws of Motion apply to daily living or local activity

Stage 2 — Student work may be incomplete and shows limited evidence of knowledge of forces or motion. The lab report may include a preliminary or first draft attempt on the required sections though it contains errors of science fact and reasoning.

Stage 1 — Student work is mostly incomplete and shows misconceptions relating forces and motion.

Standards Cross-References

National Science Education Standards

Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F=ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object. (Page 179)

Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter. (Page 180)

Benchmarks

The change in motion of an object is proportional to the applied force and inversely proportional to the mass. (Page 91)

All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion. (Page 91)

Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed—the "speed of light." (Page 92)

Whenever one thing exerts a force on another, an equal amount of force is exerted back on it. (Page 92)

The observed wavelength of a wave depends upon the relative motion of the source and the observer. If either is moving toward the other, the observed wavelength is shorter; if either is moving away, the wavelength is longer. Because the light seen from almost all distant galaxies has longer wavelengths than comparable light here on Earth, astronomers believe that the whole universe is expanding. (Page 92)

Waves can superpose on one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. The energy of waves (like any form of energy) can be changed into other forms of energy. (Page 92)

Level 4

Alaska Science Key Element A7

A student who meets the content standard should understand how the Earth changes because of plate tectonics, earthquakes, volcanoes, erosion and deposition, and living things (Processes that Shape the Earth).

Performance Standard Level 4, Ages 15–18

Students explain short-term and long-term transformations of the Earth's surface, including those caused by living things and human intervention.

Sample Assessment Ideas

- Students take a field trip to a river bank, ocean beach, or other area affected by a recent storm; observe, examine and record the damage of a storm; discuss changes to habitats; discuss how changes in plant, animal, and human activity in the area increased or decreased these changes
- Students investigate the effects of an oil spill; predict long-term environmental changes

Standards Cross-References

National Science Education Standards

Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the Earth's original formation. (Page 189)

The outward transfer of Earth's internal heat drives convection circulation in the mantle which propels the plates comprising Earth's surface across the face of the globe. (Page 189)

Heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents (Page 189)

The Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of geochemical cycles. (Page 189)

Movement of matter between reservoirs is driven by the Earth's internal and external sources of energy. These movements are often accompanied by a change in the physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as carbon dioxide gas, in water as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. (Page 189)

Geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Current methods includes using the known decay rates of radioactive isotopes present in rock to measure the time since the rock was formed. (Page 189)

Interactions among the solid Earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years. (Page 189)

Benchmarks

The formation, weathering, sedimentation, and reformation of rock constitute a continuing "rock cycle" in which the total amount of material stays the same as its forms change. (Page 74)

The slow movement of material within the Earth results from heat flowing out from the deep interior and the action of gravitational forces on regions of different density. (Page 74)

The solid crust of the Earth—including both the continents and the ocean basins—consist of separate plate that ride on a denser, hot, gradually deformable layer of the Earth. The crust sections move very slowly, pressing against one another in some places, pulling apart in other places. Ocean floor plates may slide under continental plates, sinking deep into the Earth. The surface layers of these plates may fold, forming mountain ranges. (Page 74)

Earthquakes often occur along the boundaries between colliding plates, and molten rock from below creates pressure that is released by volcanic eruptions, helping to build up mountains. Under the ocean basins, molten rock may well up between separating plates to create new ocean floor. Volcanic activity along the ocean floor may form undersea mountains, which can thrust above the ocean's surface to become islands. (Page 74)

Alaska Science Key Element A8a

A student who meets the content standard should understand the scientific principles and models that describe the nature of physical, chemical, and nuclear reactions (Energy Transformations).

Performance Standard Level 4, Ages 15–18

Students explain how the absorption or emission of energy is related to physical, chemical, and nuclear reactions and explains how these reactions can be quantitatively accounted for in terms of changes in arrangements of neutrons, protons, electrons, atoms or molecules.

Sample Assessment Ideas

- Students perform flame tests on Li, Na, Ba, and Cu salts; explain the observations in terms of photon emissions and energetics.
- Students write balanced equations to account for the rearrangement of atoms in chemical reactions (NOTE: teacher provides lists of reactants and products).
- Students write balanced equations to account for the rearrangement of neutrons, protons, and electrons in nuclear reactions such as radioactive decay, uranium fission, and hydrogen or helium fusion. (NOTE: teacher provides lists of reactants and products).

Expanded Sample Assessment Idea

- Students perform a standard calorimetry experiment to show that the energy release when an acid is mixed with a base depends on the exact amounts of acid and base reacted.

Materials

- ✔ solutions of 1M HCl and 1M NaOH
- ✔ styrofoam cup, a covering for the top (“take-out” coffee cups with lids)
- ✔ thermometer
- ✔ stirrer (plastic)
- ✔ graduated cylinders or burettes

Procedure

NOTE: Proper safety procedures must be followed!

Students will:

1. Measure amounts of acid and base solutions (different students in class use different amounts).
2. Measure temperature of both solutions—equilibrate at room temperature).
3. Rapidly pour both solutions into cup; attach cup covering; insert thermometer into opening in cup covering; measure temperature as a function of time; record and plot data.
4. Compare results with other students in class who used different amounts of solutions.

Reflection and Revision

What data should be used to compare temperatures in different experiments? How reproducible is this experiment? How could the experiment be changed to reduce the variability? What is the pattern between volumes of solution used and highest temperature reached? How can the experiment be changed to standardize this data? Write the chemical equation for this reaction. What does the data tell about the reaction between and acid and a base?

Levels of Performance

Stage 4 Student work is complete, correct and shows detailed evidence of understanding the distinction between temperature, heat and the measurement of heat emitted from a chemical reaction. Measurements and observations are detailed and interpreted with logical reasoning. Discussion indicates understanding of the principle that the energy emitted in a chemical reaction is proportional to amount of reaction occurring and the need to establish correct ratios based on volumes and concentrations of the reactants.

Stage 3 Student work is mostly complete and shows some evidence of understanding the distinction between temperature, heat and the measurement of heat emitted from a chemical reaction. Measurements and observations are interpreted with logical reasoning. Discussion indicates understanding of the principle that energy emitted in a chemical reaction is proportional to the amount of reaction occurring.

Stage 2 Student work may be incomplete and shows limited understanding of distinction between temperature, heat or the measurement of heat emitted from a chemical reaction. Measurements and observations lack detail and the interpretation and discussion may show errors of reasoning.

Stage 1 Student work is mostly incomplete and contains misconceptions relating to temperature, heat and the measurement of heat emitted from a chemical reaction. Measurements, observations, interpretations and discussion, if present, are minimal, and show a lack of scientific reasoning.

Standards Cross-Referenced

National Science Education Standards

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. (Page 178)

Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes. (Page 178)

Chemical reactions occur all around us, for example in health care, cooking. cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies. (Page 179)

Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog. (Page 179)

A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions. (Page 179)

Chemical reactions can take place in time periods ranging from the few femptoseconds (10–15 seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties—including shape—of the reacting species. (Page 179)

Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes. (Page 179)

The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered. (Page 180)

Benchmarks

Atoms often join with one another in various combinations in distinct molecules or in repeating three-dimensional crystal patterns. An enormous variety of biological, chemical, and physical phenomena can be explained by changes in the arrangement and motion of atoms and molecules. (Page 80)

The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others. (Page 80)

The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others. (Page 80)

Different energy levels are associated with different configurations of atoms and molecules. Some changes of configuration require an input of energy whereas others release energy. (Page 86)

When energy of an isolated atom or molecule changes, it does so in a definite jump from one value to another, with no possible values in between. The change in energy occurs when radiation is absorbed or emitted, so the radiation also has distinct energy values. As a result, the light emitted or absorbed by separate atoms or molecules (as in gas) can be used to identify what the substance is. (Page 86)

Energy is released whenever the nuclei of very heavy atoms, such as uranium or plutonium, split into middle weight ones, or when very light nuclei, such as those of hydrogen and helium, combine into heavier ones. The energy released in each nuclear reaction is very much greater than the energy given off in each chemical reaction. (Page 86)

Alaska Science Key Element A8b

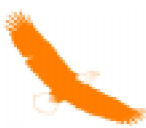
A student who meets the content standard should understand the scientific principles and models that state whenever energy is reduced in one place, it is increased somewhere else by the same amount (Energy Transformations).

Performance Standard Level 4, Ages 15–18

Students measure energy transfers that take place around them and use the data to examine The Law of Conservation of Energy.

Sample Assessment Ideas

- Students burn a candle or kerosene and measure the energy transferred to a measured amount of water; describe the relationship between energy in water and the fuel burned; identify all energy losses that occur.
- Students draw a diagram describing how photosynthesis in plants stores energy from the sun in the chemical bonds of sugars; identify energy losses to the environment.



Expanded Sample Assessment Idea

- Students trace the flow of energy from a food source to its final form; make calorimetry measurements to support these ideas

Procedure

Students will:

1. Choose 3 foods from their daily diet that they will use in calorimetry experiments (at least one food item should be an oily, fatty food.)
2. Research the calorie content of the foods.
3. Perform standard calorimetry experiments burning a measured amount of one food to heat a measured amount of water.
4. Complete the calculations to determine energy content of food; identify corrections for energy losses
5. Create a poster or model that traces energy inputs beginning with solar energy source, and showing all energy conservations

Reflection and Revision

Create poster or model to display energy information. Include an error analysis—what are the sources of error? How can the experimental design be modified to significantly reduce the energy loss?

Levels of Performance

Stage 4 — Student work is complete, correct, and shows detailed evidence of knowledge related to food energy, energy transfer and the Law of Conservation of Energy. Poster or model includes three foods, their calorie content; data and calculations using appropriate units from calorimetry experiment, and a detailed error analysis that includes modification to experimental design.

Stage 3 — Student work is mostly complete, correct, and shows evidence of knowledge related to food energy and energy transfers, but may contain minor errors or omissions. Poster or model includes three foods, their calorie content; data and calculations from calorimetry experiment that may be represented without appropriate units, and a discussion of experimental error and how to reduce experimental errors

Stage 2 Student work may be incomplete and show limited evidence of knowledge related to food energy or energy transfers. Poster or model may show evidence of skilled craftsmanship but contain limited information related to food types, calorie content, and the calorimetry experiment.

Stage 1 Student work is mostly incomplete, incorrect, shows evidence of major misconceptions relating to energy and energy transfers.

Standards Cross-References

National Science Education Standards

The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered. (Page 180)

All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves. (Page 180)

Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter. (Page 180)

Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance. (Page 180)

Benchmarks

Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount. (Page 86)

Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it. (Page 86)

Level 4

Alaska Science Key Element A8c

A student who meets the content standard should understand the scientific principles and models that state that whenever there is a transformation of energy, some energy is spent in ways that make it unavailable for use (Energy Transformations).

Performance Standard Level 4, Ages 15–18

Students explain entropy and its affect on energy availability.

Sample Assessment Ideas

- "It is easier to mess things up than to put them in order." This is often used as a way to show the idea of entropy as something happening in all the environment. Choose three examples from your home or community that seem to demonstrate this quote and explain why they do so.
- Students draw posters or diagrams and use them to explain all the energy and entropy changes happening in a snowmobile, including within the engine, and why all the energy from burning the fuel in the engine doesn't go into driving the snowmobile forward. What is becoming less ordered as the snowmobile operates?

Expanded Sample Assessment Idea

- Students observe the following changes themselves or as demonstrations, and explain why they happen with special reference to energy and entropy changes

Procedure

Students will:

1. Observe systems before and after a change has occurred. Suggested systems include:
   - Leave a saturated sugar solution on the window ledge; sugar crystals appear in a while
   - Stir solid ammonium thiocyanate crystals with barium hydroxide crystals
   - Hit a small rubber ball many times against a wall causes the ball to heat up.
   - Mix ammonium sulfate crystals and water
   - Activate a drug store or athletic department "cold pack" or "hot pack".
2. Carefully record observations
3. Measure heat effects using a thermometer (before and after); record and tabulate results
4. Build models to demonstrate what happens in the change.
5. Use the model as part of an oral presentation on what happens.

Reflection and Revision

Find one clear example of a similar change that demonstrates an entropy effect in the community/environment and create a poster to explain this to a parent group.

Levels of Performance

Stage 4 — Student work is complete, and shows clear understanding of kinetic and positional energy (entropy) and how these relate to processes and change. Measurements, data, observations, and inferences are detailed and accurate. An accurate model and poster are created, and used to effectively explain energy and entropy interactions.

Stage 3 — Student work is mostly complete, and shows understanding of kinetic and positional energy (entropy) and how these relate to processes and change. Measurements, data, observations, and inferences are appropriate, although they may contain minor errors or omissions. A reasonable model and poster are created, and used to describe energy and entropy interactions.

Stage 2 — Student work may be incomplete, and shows limited understanding of kinetic or positional energy (entropy) or how they relate to processes and change. Measurements, data, observations, and inferences are incomplete, incorrect or lack detail and logical reasoning. Model and poster may show evidence of skilled craftsmanship but cannot be used to describe energy interactions.

Stage 1 — Student work is mostly incomplete, and shows little or no understanding of energy or entropy. Data and observations are incomplete or incorrectly recorded. Model and poster may show evidence of skilled craftsmanship but are inaccurate and do not support explanations.

Standards Cross-References

National Science Education Standards

Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion. (Page 180)

The total energy of the Universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered. (Page 180)

Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels. (Page 180)

Benchmarks

Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began—that is, with the heat energy spread out more evenly. With large numbers of atoms and molecules, the greater disorder is almost certain. (Page 86)

Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it. (Page 86)

Alaska Science Key Element A9

A student who meets the content standard should understand the transfers and transformations of matter and energy that link living things and their physical environment from molecules to ecosystems (Flow of Matter and Energy).

Performance Standard Level 4, Ages 15–18

Students describe the relationship between energy and matter in a biological system.

Sample Assessment Ideas

- Students use different colored lights to grow elodea; count bubbles; draw conclusions
- Students create a poster that compares the calorie content of equal masses of protein, carbohydrate, and lipid; discuss efficient energy storage mechanisms in a variety of plant and animal organisms
- Students explain biomass conversions that take place in a simple food chain. (For example, sunlight to plants, plants to mice, mice to snakes.)

Standards Cross-References

National Science Education Standards

Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. (Page 184)

The atoms and molecules on Earth cycle among the living and non-living components of the biosphere. (Page 186)

Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers. (Page 186)

All matter tends toward more disorganized states. Living systems require a continuous input of energy to maintain their chemical and physical organizations. With death, and the cessation of energy input, living systems rapidly disintegrate. (Page 186)

The energy for life primarily derives from the sun. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. These molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars, and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes. (Page 186)

The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Cells usually store this energy temporarily in phosphate bonds of a small high-energy compound called ATP. (Page 186)

The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy, and by the ability of the ecosystem to recycle materials. (Page 186)

As matter and energy flows through different levels of organization of living systems–cells, organs, organisms, communities-and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change. (Page 186)

Benchmarks

At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. By burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide. (Page 121)

The amount of life any environment can support is limited by the available energy water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land. (Page 121)

The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going. (Page 121)

Level 4

Alaska Science Key Element A10

A student who meets the content standard should understand that living things are made up mostly of cells and that all life processes occur in cells (Cells).

Performance Standard Level 4, Ages 15–18

Students identify structure-function relationships at the subcellular, cellular, tissue, organ, and organism levels of organization.

Sample Assessment Ideas

- Students correctly identify basic cell organelles using samples of prepared cells from plants and animals; describe the function of basic cell organelles
- Students research protective responses that plants display against herbivores; examine the physical and chemical properties of these defensive adaptations

Expanded Sample Assessment Idea

- Students dissect a plant that grows and survives in the northern Alaska environment; identify environmental adaptations at the organism, tissue, and cellular level.

Procedure

Students will:

1. Draw the original plant including an image made from examination with a magnifying lens; label all structures and the epidermal covering of the plant, including the covering of stems, roots, and leaves.
2. Prepare samples for microscopic observation; view under low and high power magnification; draw and label.
3. Collect information about the shape and function of specialized cells, tissues, and organs needed to endure cold temperatures, high winds, frozen and scarce water
4. Discuss cellular adaptations to environmental conditions (e.g. how cells of a tropical plant differ from an arctic plant.)

Reflection and Revision

What other location would require such plant adaptations?

Level of Performance

Stage 4 — Student work clearly and accurately explains how cell, tissue, and organ level adaptations help an organism survive in its environment. The structure-function relationship of specialized cells, tissues, and organs are each described in detail.

Stage 3 — Student work accurately explains how cell, tissue, and organ level adaptations help an organism survive in is environment. Some structure-function relationships of specialized cells, tissues, and organs are described.

Stage 2 — Student work attempts to describe cells, tissues, or organs in one or more organisms but descriptions of structure-function relationships are incomplete, incorrect, and may contain errors of science fact and reasoning.

Stage 1 — Student work is largely incomplete, incorrect, and contain errors of science fact and reasoning.

Standards Cross-References

National Science Education Standards

Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material. (Page 184)

Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell. (Page 184)

Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. (Page 184)

Cell functions are regulated. Regulation occurs both through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environment and to control and coordinate cell growth and division. (Page 184)

Plant cells contain chloroplasts, the site of photosynthesis. Plants and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy rich organic compounds and release oxygen to the environment. This process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. (Page 184)

Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues, and organs that comprise the final organism. This differentiation is regulated through the expression of different genes. (Page 184)

Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them. (Page 187)

Benchmarks

Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement. (Page 113)

Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback, and even movement. In addition to these basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not. (Page 113)

The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the chain's parts. (Page 114)

The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms. Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on. (Page 114)

Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms. (Page 114)

Gene mutation in a cell can result in uncontrolled cell division called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. (Page 114)

Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact. Both single cells and multicellular organisms have molecules that help to keep the cell's acidity within a narrow range. (Page 114)

A living cell is composed of a small number of chemical elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur. Carbon atoms can easily bond to several other carbon atoms in chains and rings to form large and complex molecules. (Page 114)

Alaska Science Key Element A11

A student who meets the content standard should understand that similar features are passed on by genes through reproduction (Heredity).

Performance Standard Level 4, Ages 15–18

Students build a model to show how the structure of DNA affects the structure of proteins, cells, and ultimately phenotypic characteristics of the organism.

Sample Assessment Ideas

- Students research and discuss the process of gene splicing beginning with the initial steps of gene identification; use this research to debate the ethics of whether or not human genes should be spliced into species of plants and animals.
- Students describe the difference between the DNA of a large local animal and the DNA of a mosquito.

Standards Cross-References

National Science Education Standards

In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome. (Page 185)

Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: a female contains two X chromosomes and a male contains one X and one Y chromosome. Transmission of genetic information to offspring occurs through egg and sperm cells that contain only one representative from each chromosome pair. An egg and a sperm unite to form a new individual. The fact that the human body is formed from cells that contain two copies of each chromosome-and therefore two copies of each gene—explains many features of human heredity, such as how variations that are hidden in one generation can be expressed in the next. (Page 185)

Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring. (Page 185)

Benchmarks

Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious (Page 108)

The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents. (Page 108)

The information passed from parents to offspring is coded in DNA molecules (Page 108)

Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment. (Page 109)

Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to descendant cells only. The experiences an organism has during its lifetime can affect its offspring only if the genes in its own sex cells are changed by the experience. (Page 109)

The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different parts of the instructions are used in different types of cells, influenced by the cell's environment and past history. (Page 109)

Level 4

Alaska Science Key Element A12

A student who meets the content standard should distinguish the patterns of similarity and differences in the living world in order to understand the diversity of life and understand the theories that describe the importance of diversity for species and ecosystems (Diversity).

Performance Standard Level 3, Ages 11–14

Students describe how diversity and genetic variability influence a species' survival rate under changing environmental conditions

Sample Assessment Ideas

- Students closely study the features of at least five samples of a local species harvested in season (for example, five seals); identify similarities and differences
- Students explain why diversity is important for the health of ecosystems

Expanded Sample Assessment Idea

- Students compare algae and land plants; identify divergence as well as similarity; discuss the effect that adaptation has had on plant diversification and survival.

Procedure

Students will:

1. Investigate energy production in algae and land plants
2. Use microscopes to compare the structures of both plants; draw and label diagrams of the structures, and identify the location of energy production.
3. Classify algae and land plants according to their structures and energy production.
4. Identify environmental needs of algae and plants including different structures and energy production.
5. Make an oral presentation to the class
6. As a group, discuss various algae species including classification, cellular- and structural-adaptations; discuss various land plant species including classification (monocot vs dicot, gymnosperm vs angiosperm), cellular and structural-adaptations; discuss energy harnessing in algae vs land plants.

Reflection and Revision

What specific structures must be observed to study energy productions? Describe the biochemical, cellular, and structural adaptations of several algae and land plant species.

Level of Performance

Stage 4 — Student work is complete, and shows evidence of logical reasoning. Diagrams are detailed, correctly identify classification schemes for both algae and land plants, and include detailed comparisons of cellular and structural adaptations in both land and aquatic plants

Stage 3 — Student work shows evidence of logical reasoning but may contain minor errors or omissions. Diagrams correctly identify a classification scheme for both algae and land plants, and compare some cellular or structural adaptations

Stage 2 — Student work may be incomplete, incorrect, and may contain errors of science fact and reasoning. Diagrams correctly identify algae and land plants and develop a simple classification scheme

Stage 1 — Student work is largely incomplete, incorrect, or contains evidence of misconceptions related to plants, plant classification, and plant adaptation.

Standards Cross-References

National Science Education Standards

The great diversity of organisms is the result of more than 3.5 billion years of evolution which has filled every available niche with life forms. (Page 185)

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their evolutionary relationships. Species is the most fundamental unit of classification. (Page 185)

Benchmarks

The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions, and a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment. (Page 105)

The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification which is based on anatomical similarities. (Page 105)

Alaska Science Key Element A13

Level 4

A student who meets the content standard should understand the theory of natural selection as an explanation for evidence of changes in life forms over time (Evolution and Natural Selection).

Performance Standard Level 4, Ages 15–18

Students use the theory of natural selection to explain changes in life forms over time.

Sample Assessment Ideas

- Students watch a film about prehistoric time; retell the story using the theory of natural selection and plate tectonics.
- Students describe a modern day example of evolutionary change, such as antibiotic resistant bacteria, rapidly mutating viruses, pesticide-resistant insects, or herbicide-resistant weeds.

Expanded Sample Assessment Idea

- Students use information and evidence collected by scientists in the fields of geology, physical anthropology, embryology, molecular biology and evolutionary biology to support the theory of change over time; apply the information to create a board game.

Procedure

Students will:

1. Assign role of geologist, physical anthropologist, embryologist, molecular biologist and evolutionary biologist to the members of their five-person team; each team member will become a subject-matter expert in their field.
2. Collect information to support the statement: "The Earth and living organisms have changed over time."
3. Each team uses collected information to create a board game entitled: "The History of Earth and Life Forms" that uses information collected in each subject matter area. Teams play each game to determine if team members understand each of the content areas.
4. Regroup in subject matter expert groups; play each game to determine accuracy of information related to their content area; rate each game for accuracy and completeness of content area knowledge.

Reflection and Revision

How could all teams have performed better during the games?

Level of Performance

Stage 4 — Board game incorporates six or more pieces of information from each content area, and shows extensive evidence of knowledge related to the theory of natural selection, evolution, and change over time. Game includes detailed instructions for how to play.

Stage 3 — Board game incorporates four or more pieces of information from each content area, and shows evidence of knowledge related to the theory of natural selection, evolution, and change over time. Game includes most instructions for how to play.

Stage 2 — Board game uses at least two pieces of information from each content area, but shows limited evidence of knowledge related to the theory of natural selection, evolution, or change over time. Game includes limited instructions for how to play.

Stage 1 — Board game is incomplete, and shows misconceptions or little evidence of understanding of natural selection, evolution, or change over time.

Standards Cross-References

National Science Education Standards

Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. [See Unifying Concepts and Processes] (Page 185)

The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms. (Page 185)

Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. (Page 185)

The millions of different species of plants, animals, and microorganisms that live on Earth today are related by descent from common ancestors. (Page 185)

Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification. (Page 185)

Benchmarks

The basic idea of biological evolution is that the Earth's' present-day species developed from earlier, distinctly different species. (Page 125)

Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another. (Page 125)

Natural selection provides the following mechanism for evolution: Some variation in heritable characteristics exists within every species, some of these characteristics give individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase. (Page. 125)

Heritable characteristics can be observed at molecular and whole-organism levels-in structure, chemistry, or behavior. These characteristics strongly influence what capabilities an organism will have and how it will react, and therefore influence how likely it is to survive and reproduce. (Page 125)

New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Changes in other cells of an organism can not be passed on to the next generation. (Page 125)

Natural selection leads to organisms that are well suited for survival in particular environments. Changes alone can result in the persistence of some heritable characteristics having no survival or reproductive advantage or disadvantage for the organism. When an environment changes, the survival value of some inherited characteristics may change. (Page 125)

The theory of natural selection provides a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms. (Page 125)

Life on Earth is thought to have begun as simple, one-celled organisms about 4 billion years ago. During the first 2 billion years, only single-cell microorganisms existed, but once cells with nuclei developed about a billion years ago, increasingly complex multi-cellular organisms evolved. (Page 125)

Evolution builds on what already exists, so the more variety there is, the more there can be in the future. But evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush: some branches survive from the beginning with little or no change, many die out altogether, and others branch repeatedly, sometimes giving rise to more complex organisms. (Page 125)

Level 4

Alaska Science Key Element A14a

A student who meets the content standard should understand the interdependence between living things and their environments (Interdependence).

Performance Standard Level 4, Ages 15–18

Students classify living organisms based on inter- and intra-community relationships, and describe how organisms and groups of organisms affect the environment.

Sample Assessment Ideas

- Students prepare a written report on an assigned plant or animal including how it affects the ecosystem in which it lives
- Students report on the ways that plants disperse their seeds and the effect of seed dispersal on ecological succession.

Expanded Sample Assessment Idea

- Students investigate environmental problems caused by the introduction of non-indigenous plants or animals into an ecosystem.

Procedure

Students will:

1. Discuss with Elders and collect information regarding the identity and historical aspects of exogenous plants or animals that have been introduced into their locale
2. Produce a report describing the effects of the introduction and how it has modified the local environment.

Reflection and Revision

Discuss the growth constraints and the limitations of the introduced species in the new environment. Discuss positive and negative effects of introduction of exogenous species; discuss natural invasion vs human-mediated invasion of exogenous species

Level of Performance

Stage 4 Student work is complete, and shows evidence of logical reasoning. The investigation and written report show extensive evidence of knowledge related to inter- and intra-community relationships; and how the introduction of exogenous organisms affects the environment. The report explains in detail the chain of events leading to the environmental problem including species competition, animal behavior, and plant growth and development. The report shows detailed evidence of transfer and extension of knowledge in a multi-faceted discussion of natural invasion vs human-mediated invasion of exogenous species

Stage 3 Student work shows evidence of logical reasoning, but may contain minor errors or omissions. The investigation and written report show evidence of knowledge related to inter- and intra-community relationships, and how the introduction of exogenous organisms affects the environment. The report explains the chain of events leading to the environmental problem some aspects of species competition, animal behavior and development, or plant growth and development. The report also shows evidence of transfer and extension of knowledge in a discussion of natural invasion vs. human-mediated invasion of exogenous species

Stage 2 — Student work is incomplete, or contains errors of science fact and reasoning. The investigation and written report show limited evidence of knowledge related to environmental problems associated with the introduction of non-indigenous organisms or the impact of human-mediated invasion vs. natural invasion.

Stage 1 — Student work is largely incomplete, and contains misconceptions regarding non-indigenous organisms and the environment.

Standards Cross-References

National Science Education Standards

Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. (Page 186)

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms. (Page 186)

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected. (Page 186)

The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy, and the ability of the ecosystem to recycle materials. (Page 186)

Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations. (Page 198)

The Earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that can not be renewed. (Page 198)

Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically. (Page 198)

Benchmarks

Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, and disease or parasites. If a disaster such as a flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. (Page 117)

Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. (Page 117)

Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. (Page 117)

Alaska Science Key Element A14b

A student who meets the content standard should understand that the living environment consists of individuals, populations, and communities (Interdependence).

Performance Standard Level 4, Ages 15–18

Students describe plant and animal population interactions within various communities and biomes.

Sample Assessment Ideas

- Students tour a local ecosystem and write a description of the major components of that ecosystem.
- Students study the population cycles of willows and moose on Isle Royale.

Expanded Sample Assessment Ideas

- Students identify a community and create an inventory of the plant and animal species.

Procedure

Students will:

1. Choose a small, well-defined outdoor area and make an inventory of all the plants and animals they find using identification booklets and ecological survey counting techniques.
2. Work separately in their own areas, then compile the class results.
3. Determine the type of community; describe its general characteristics; identify similarities and differences between the area of class study and other communities of the same type.

Reflection and Revision

Discuss the accuracy of the survey methods. Suggest how plant and animal population interactions may differ in an aquatic vs. terrestrial environment, a marine vs. freshwater environment, a natural vs. man-made (zoo or farm) environment. Discuss how the components work together to create the ecosystem.

Level of Performance

Stage 4 — Student work is complete, shows extensive evidence of knowledge of plant and animal interactions within biomes and evidence of logical reasoning. Student inventory includes: a list of most plant and animal species along with correct identification and population counts; a detailed description of the community and comparison of this specific community to the generalized biome type. Student report shows extensive transfer of knowledge and extension of knowledge in the detailed discussion of how plant and animal interactions vary in different biomes, as well as in man-made vs. natural environments.

Stage 3 — Student work shows evidence of knowledge of plant and animal interactions within biomes as well as logical reasoning but may contain minor errors or omissions. Student inventory includes: a list of plant and animal species along with identification and population counts that are mostly correct; a description of the community and comparison of this specific community to the generalized biome type. Student report shows transfer of knowledge and extension of knowledge in a discussion of how plant and animal interactions vary in different biomes, or in man-made vs. natural environments.

Stage 2 — Student work is incomplete, shows limited evidence of knowledge related to plant and animal interactions or characteristics of biomes and may contain errors of science fact and reasoning. Student inventory includes: a partial listing of plant and animal species along with some identification or population counts. The inventory may lack a description of the community or comparison of this specific community to the generalized biome type. A discussion of plant and animal interactions and different man-made or natural biomes may be absent.

Stage 1 — Student work is largely incomplete, shows little evidence of understanding and may contain major misconceptions related to plant and animal interactions and biomes.

Standards Cross-References

National Science Education Standards

Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. (Page 186)

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms. (Page 186)

Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution. (Page 198)

Populations can reach limits to growth. Carrying capacity is the maximum number of individuals that can be supported in a given environment. The limitation is not the availability of space, but the number of people in relation to resources and the capacity of Earth systems to support human beings. Changes in technology can cause significant changes, either positive or negative, in carrying capacity. (Page 198)

Benchmarks

Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as a flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. (Page 117)

Level 4

Alaska Science Key Element A14c

A student who meets the content standard should understand that a small change in a portion of an environment may affect the entire environment (Interdependence).

Performance Standard Level 4, Ages 15–18

Students describe the health of a local ecosystem using the parameters of population size, species diversity and productivity.

Sample Assessment Ideas

- Students investigate changes in caribou population, health, and breeding grounds associated with the development of the oil industry on the North Slope of Alaska.
- Students investigate the historic biomass of a local salmon stock by comparing data from local oral histories with local, state, and federal agency data; estimate the overall health of that stock; discuss the value of using data from more than one source

Standards Cross-References

National Science Education Standards

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms. (Page 186)

Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organisms' own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli. (Page 187)

Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans. (Page 198)

Materials from human societies affect both physical and chemical cycles of the Earth. (Page 198)

Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and the different ways humans view the Earth. (Page 198)

Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change. (Page 199)

Benchmarks

Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, and disease or parasites. If a disaster such as a flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. (Page 117)

Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. (Page 117)

Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. (Page 117)

Level 4

Alaska Science Key Element A15

A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

Performance Standard Level 4, Ages 15–18

Students recommend a management strategy to solve a local environmental problem related to resource utilization such as fish and game, building permits, mineral rights, and land use policies.

Sample Assessment Ideas

- Students explore the watershed management in their local area and recommend alternative strategies they think would be beneficial for the local fish and wildlife.
- Students investigate the source of the community's water and its waste disposal system; recommend improvements beneficial to the local fish and wildlife.

Expanded Sample Assessment Idea

- Students hypothesize which factors should be considered to predict when Alaska herring fisheries will open. Factors include surface water temperature, weather, wind, tides, roe percents, projected age, and so on. Students will use Internet, printed reference material, and interviews with knowledgeable people.

Procedure

Students will:

1. Collect samples of fish of specific ages; examine fish scales using a hand lens and a microscope; draw observations; write a generalization that can be used to determine the age of a fish using microscopic observations of fish scales.
2. Interview Elders, local fishermen, and knowledgeable outdoorsmen; discuss how they predict the arrival and time of spawning. Questions should include: How did they learn to look for these predicting signs? How close do their predictions usually come to actual fishery opening dates? What is the outcome when their prediction dates are wrong? What kind of "window" of correct prediction is important to them?
3. Form teams of 3–4 students with each team assigned a herring fishery; based on fishery location, the group decides which factors play primary roles in predicting the opening date of the fishery; each student on the team becomes the subject-matter expert for one or more factors.
4. Use a variety of research resources to collect information about the variables being studied, (for example, Internet, Department of Fish and Game, National Oceanographic and Aeronautic Association (NOAA) records, meteorological records, and so on).
5. Based on research, each team will predict the herring fishery opening.
6. Student predictions will be compared to actual openings.

Reflection and Revision

Based on the results of their site, teams modify their hypothesis and factors for subsequent fishery openings.

Level of Performance

Stage 4 — Student research incorporates multiple sources of information. Data collected is extensive, and relevant to the conditions at the assigned fishery site. Student's work demonstrates extensive evidence of knowledge related to environmental problem solving.

Stage 3 — Student research incorporates several sources of information. Data collected is relevant to the conditions at the assigned fishery site. Student work demonstrates some evidence of knowledge related to environmental problem solving. Minor misconceptions may be evident.

Stage 2 — Student research uses limited sources of information. Data collected is relevant to the conditions at the assigned fishery but lack detail. Students work demonstrates limited evidence of knowledge related to environmental problem solving. Student work may be incomplete, incorrect, lacking detail, or contain errors of reasoning.

Stage 1 — Students research may be on topic, but is limited in scope. Data shows little or no evidence relating to the assigned fishery site. Students work is largely incomplete, incorrect, and may show major misconceptions

Standards Cross-References

National Science Education Standards

Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. (Page 186)

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms. (Page 186)

Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability and if not addressed, ecosystems will be irreversibly affected. (Page 186)

Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations. (Page 198)

Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically. (Page 198)

Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans. (Page 198)

Materials from human societies affect both physical and chemical cycles of the Earth. (Page 198)

Benchmarks

The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions. A great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment. (Page 105)

Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one. (Page 117)

Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. (Page 117)

Mini-Unit: When Will the Herring Fisheries Open?

Performance Standard A15, Level 4

Students recommend a management strategy to solve a local problem related to resource utilization such as fish and game, building permits, mineral rights. and land use policies.

Key Concepts and Skills

- The opening of commercial fisheries is directly correlated to herring sexual maturation, as measured by roe percent.
- Herring maturation is correlated to several major environmental factors, including surface water temperature, weather, wind, tides, roe percents, projected age, and so on.
- Microscopic examination of fish scales provides clues related to the age of fish.
- Weather and tides affect the time of spawning.
- Arithmetic skills include percent calculation and metric-to-American unit conversions

Timeline

One week in early spring to design and setup experiments followed by weekly monitoring (about 1/2 hour per week) from mid-March to the end of school.

Abstract

Students design class research project that will investigate the factors used to estimate when Alaska herring fisheries will open. Each student on the team is responsible for monitoring data related to the factor or factors in which they become subject matter experts. Each student team is responsible for collecting information and data relevant to a fishery within the state.

Alaska Science Content Standard Key Element

A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

Cross-Reference

Additional Content and Performance Standards: A4, B3, D2, and D3. Cultural Standards C2, C4, and C6.

Materials

- ✔ Access to previous harvest records including quantity and time of harvest, water temperatures, age-class outbreak of herring harvest, and stock.
- ✔ Access to Internet information on weather and herring fisheries

Activities

1

Collect samples of fish of specific ages; examine fish scales using a hand lens and microscope; draw your observations; write a generalization that can be used to determine the age of a herring using microscopic observations of herring scales

Embedded Assessment

Check for student understanding by examining drawings and generalizations made about the appearance of scales and age of the fish.

2

Interview Elders, local fishermen, and knowledgeable outdoorsmen; discuss how they predict the arrival of herring and time of spawning. How did they learn to look for these predicting signs? How close do their predictions usually come to actual fishery opening dates? What is the outcome when their prediction dates are wrong? What kind of "window" of correct prediction is important to them?

Embedded Assessment

After consultations, form teams of 3–4 students and assign a specific herring factory to each. Based on the factory location, the group decides which factors will play the primary role in predicting the opening date of the fishery. Each student on the team will become the subject-matter expert for one or more factors.

3

Use a variety of research resources to collect information about the variables being studied (for example, Internet, Fish and Game Department, National Oceanographic and Aeronautic Association (NOAA) records, meteorological records and so on).

Embedded Assessment

Based on research each team will predict the herring fishery opening.

4

Each team will develop a list of factors they will use to estimate the opening for each fishery being considered. Each team member is responsible for monitoring the factor or factors which they are expert in. Based on their factors they will monitor statewide weather conditions to estimate the openings of the fisheries. Student predictions will be compared to actual openings. Based on the results of their site, teams modify their hypothesis and factors for subsequent fishery openings

Level of Performance

Stage 4 — Student research incorporates multiple sources of information. Data collected is extensive, and relevant to the conditions at the assigned fishery site. Student work demonstrates extensive evidence of knowledge related to environmental problem solving.

Stage 3 — Student research incorporates several sources of information. Data collected is relevant to the conditions at the assigned fishery site. Student work demonstrates some evidence of knowledge related to environmental problem solving. Minor misconceptions may be evident.

Stage 2 — Student research uses limited sources of information. Data collected is relevant to the conditions at the assigned fishery, but lack detail. Students work demonstrates limited evidence of knowledge related to environmental problem solving. Student work may be incomplete, incorrect, lacking detail, or contain errors of reasoning.

Stage 1 — Students research may be on topic, but is limited in scope. Data shows little or no evidence relating to the assigned fishery site. Students work is largely incomplete, incorrect, and may show major misconceptions

Standards Cross-References

National Science Education Standards

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Materials from human societies affect both physical and chemical cycles of the earth. (Page 198)

Benchmarks

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Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. (Page 117)

Alaska Science Key Element A16

A student who meets the content standard should understand basic concepts about the Theory of Relativity, which changed the view of the universe by uniting matter and energy and by linking time with space (Relativity).

Performance Standard Level 4, Ages 15–18

Students describe how studying radioactive decay, nuclear fission, and fusion can provide evidence confirming the Law of Conservation of Matter and Energy.

Sample Assessment Ideas

- Students perform mass-energy calculations on nuclear reactions to show how the relativistic equation $E = mc^2$ predicts how much energy is released in: a radioactive decay, a nuclear fission reaction of uranium, and a nuclear fusion reaction of a deuterium (H^2) and tritium (H^3) atom; explain what degree of accuracy is required on the initial mass in order to complete such calculations
- Students read "Relativity Visualized" by Lewis Carroll Epstein, (publisher—Insight Press, San Francisco); explain ONE of the ideas using diagram from the book.

Expanded Sample Assessment Idea

Procedure

Students will:

1. Be instructed that it is a fact that the Earth is flat. Challenge them to prove that it is not. (See attached lists for historical arguments for and against). As debate slows also say that the Earth doesn't turn. Continue to stir up the debate The students should leave the room debating each other and arrive in class the next day with a proof that the Earth is round and spins
2. Be assigned one of the following people to research: Ptolemy, Copernicus, Galileo, Kepler, Newton, Tycho Brache, Albert Einstein, Stephen Hawking, Neil Armstrong, Sally Ride Use all research avenues available, including Internet. Students should find out the personal history of the scientist as well as the major contributions to science and society.
3. Invite Elders to share beliefs and legends related to topic.
4. Develop a timeline, including the results of the previous research. The timeline should include names and important contributions, tracing the development of the geocentric view to the heliocentric view. In the development of the principles, it is very important that the societal context of the era be emphasized.
5. Hold a mock trial of Galileo that includes Ptolemy, Copernicus, Johannes Kepler, Tycho Brache, Isaac Newton, Albert Einstein, Stephen Hawking, Neil Armstrong, and Sally Ride as witnesses. "The Copernican Revolution illustrates some of the strains that can occur between science and society when science proposes ideas that seem to violate common sense or to undermine traditional values and beliefs. This part of the story should be included but not presented as the triumph of right over wrong or of science over religion." (from Benchmarks, p. 240)

Levels of Performance

Stage 4 — Student actively participates in mock trial and demonstrates mastery of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work is correct, complete and shows evidence of logical reasoning.

Stage 3 — Student actively participates in mock trial and demonstrates knowledge of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work shows evidence of logical reasoning but may contain minor errors or omissions.

Stage 2 — Student reluctantly participates in mock trial and demonstrates limited knowledge of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work may be incomplete, incorrect and may contain errors of science fact and reasoning.

Stage 1 — Student may be a non-participant in mock trial. Student work is largely incomplete, incorrect, shows little evidence of understanding and may contain major misconceptions.

Standards Cross-References

National Science Education Standards

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. (Page 178)

The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered. (Page 180)

Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. Examples of such advances include the following:

- Copernican revolution
- Newtonian mechanics
- Relativity
- Geologic time scale
- Plate tectonics
- Atomic theory
- Nuclear physics
- Biological evolution
- Germ theory
- Industrial revolution
- Molecular biology
- Information and communication
- Quantam theory
- Galactic universe
- Medical and health technology

Benchmarks

As a young man, Albert Einstein, a German scientist, formulated the special Theory of Relativity, which brought about revolutionary changes in human understanding of nature. A decade later, he proposed the general Theory of Relativity, which, along with Newton's work, ranks as one of the greatest human accomplishments in all of history. (Page 245)

Among the surprising ideas of special relativity is that nothing can travel faster than the speed of light, which is the same for all observers no matter how they or the light source happen to be moving. (Page 245)

The special Theory of Relativity is best known for stating that any form of energy has mass, and that matter itself is a form of energy. The famous relativity equation, E = mc2, holds that the transformation of even a tiny amount of matter will release an enormous amount of other forms of energy, in that the c in the equation stands for the immense speed of light. (Page 245)

General relativity theory pictures Newton's gravitational force as a distortion of space and time. (Page 245)

Many predictions from Einstein's Theory of Relativity have been confirmed on both atomic and astronomical scales. Still, the search continues for an even more powerful theory of the architecture of the universe. (Page 245)

The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. A mathematical model may give insight about how something really works or may fit observations very well without any intuitive meaning. (Page 270)

Mini-Unit: Copernican Revolution

Performance Standard A16, Level 4

Students describe one of the basic tenets of special relativity such as time dilation, length contraction, the space-time continuum, or The Law of Conservation of Matter and Energy.

Key Concepts and Skills

- Geocentricity heliocentricity
- Personal histories of early astronomers (i.e. Copernicus, Galileo)
- Special Relativity
- Personal history of present-day cosmologists (i.e. Einstein, Hawking)

Timeline

10 days

Abstract

By treating relativity historically in high school, it is possible to avoid falling into the trap of trying to teach (Special Relativity's) technical and mathematical details. The main goals should be for students to see that Einstein went beyond Newton's world view by including it as a limiting case in a more complete theory. (from Benchmarks, p. 245)

This unit starts with a debate about accepted facts and ends with a mock trial of Galileo that includes input from the present day cosmologists, Albert Einstein and Stephen Hawking.

Alaska Science Content Standard Key Element

A student who meets the content standard should understand basic concepts about the Theory of Relativity, which changed the view of the universe by uniting matter and energy and by linking time with space (Relativity).

Cross-Reference

Additional Content and Performance Standards: A3, C3, C5, C6, C7. Cultural Standard A1

Materials

- ✔ Access to computers and Internet
- ✔ Library resources
- ✔ Guidelines for debate (language arts book) and mock trial

Activities

Gear-up

Tell the students that is a fact that the earth is flat. Challenge them to prove that it is not. (See attached lists for historical arguments for and against). As debate slows also say that the earth doesn't turn. Continue to stir up the debate. The students should leave the room debating each other and arrive in class the next day with a proof that the earth is round and spins

Embedded Assessment

Listening skills, being able to validate others' opinions, etc.

1

In cooperative groups, assign one of the following to research: Ptolemy, Copernicus, Galileo, Kepler, Newton, Tycho Brache, Albert Einstein, Stephen Hawking, Neil Armstrong, Sally Ride. Use all research avenues available, including Internet. Students should find out the personal history of the scientist as well as the major contributions to science and society.

Embedded Assessment

Research skills, use of the Internet, web page analysis, working in cooperative groups, etc.

2

Invite Elders to share beliefs and legends related to topic

3

Have students develop a timeline, including the results of the previous research. The timeline should include names and important contributions, tracing the development of the geocentric view to the heliocentric view. In the development of the principles, it is very important that the societal context of the era be emphasized.

Embedded Assessment

Content knowledge

4

Hold a mock trial of Galileo that includes Ptolemy, Copernicus, Johannes Kepler, Tycho Brache, Isaac Newton, Albert Einstein, Stephen Hawking, Neil Armstrong and Sally Ride as witnesses. "The Copernican Revolution illustrates some of the strains that can occur between science and society when science proposes ideas that seem to violate common sense or to undermine traditional values and beliefs. This part of the story should be included but not presented as the triumph of right over wrong or of science over religion." (from Benchmarks, p. 240)

Expanded Sample Assessment

Levels of Performance

Stage 4 — Student actively participates in mock trial and demonstrates mastery of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work is complete, correct and shows evidence of clear and logical reasoning.

Stage 3 — Student actively participates in mock trial and demonstrates knowledge of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work shows evidence of clear and logical reasoning but may contain minor errors or omissions

Stage 2 — Student reluctantly participates in mock trial and demonstrates limited knowledge of the historical-viewpoint appropriate to his / her character or position within the courtroom. Student work may be incomplete, incorrect and may contain errors of science fact and reasoning.

Stage 1 — Student may be a non-participant in mock trial. Student work is largely incomplete, incorrect, shows little evidence of understanding and may contain major misconceptions

Standards Cross-References

National Science Education Standards

The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars. (Pg. 178)

The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered. (Pg. 180)

Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. Examples of such advances include the following: Relativity (etc) (Pg 204)

Benchmarks

As a young man, Albert Einstein, a German scientist, formulated the special Theory of Relativity, which brought about revolutionary changes in human understanding of nature. A decade later, he proposed the general Theory of Relativity, which, along with Newton's work, ranks as one of the greatest human accomplishments in all of history. (Pg. 245)

Among the surprising ideas of special relativity is that nothing can travel faster than the speed of light, which is the same for all observers no matter how they or the light source happen to be moving. (Pg. 245)

The special Theory of Relativity is best known for stating that any form of energy has mass, and that matter itself is a form of energy. The famous relativity equation, $E = mc^2$, holds that the transformation of even a tiny amount of matter will release an enormous amount of other forms of energy, in that the c in the equation stands for the immense speed of light. (Pg. 245)

General relativity theory pictures Newton's gravitational force as a distortion of space and time. (Pg. 245)

Many predictions from Einstein's Theory of Relativity have been confirmed on both atomic and astronomical scales , the search continues for an even more powerful theory of the architecture of the universe (Pg. 245)

The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. A mathematical model may give insight about how something really works or may fit observations very well without any intuitive meaning. (Pg. 270)

Alaska Science Content Standard B

Level 1, Ages 15–18

A student should possess and understand the skills of scientific inquiry.

Level 4

Alaska Science Key Element B1

A student who meets the content standard should use the processes of science; these processes include observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting, and experimenting.

Performance Standard Level 4, Ages 15–18

Students collect, analyze, and interpret qualitative and quantitative data, develop models, and suggest further experimentation to investigate and explain everyday phenomena in their world.

Sample Assessment Ideas

- Students collect and analyze data about a phenomenon in their local environment (e.g., hillside slumping, erosion, frost heaves, permafrost). Students use the information to develop a model to explain the phenomenon.
- Students observe micro climates on different sides of the school building; measure variables in those micro-climates; observe and record the types and numbers of organisms present; then infer abiotic-biotic relationships.

Standards Cross-References

National Science Education Standards

Use technology and mathematics to improve investigations and communications. A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results. (Page 175)

Formulate and revise scientific explanations and models using logic and evidence. Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation. (Page 175)

Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used. (Page 176)

Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations, and communicating results. (Page 176)

Results of scientific inquiry–new knowledge and methods–emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation. (Page 176)

Benchmarks

Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available). (Page 13)

Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns. (Page 13)

Level 4

Alaska Science Key Element B2

A student who meets the content standard should design and conduct scientific investigations using appropriate instruments

Performance Standard Level 4, Ages 15–18

Students conduct primary scientific research and use sophisticated instrumentation and technology to design, modify, and conduct a series of experiments related to a multifaceted problem in the natural or designed world.

Sample Assessment Ideas

- Students examine the viscosity of different oils and greases (Arctic and non-Arctic) at different temperatures. Identify possible effects of using each oil or grease on the performance of equipment operated in severe cold weather.
- Students determine what oils and wicks work best in traditional lamps. Variables to consider include effectiveness, durability; traditional oils (bear, moose, seal, walrus) and modern oils (kerosene, stove, cooking, motor).

Standards Cross-References

National Science Education Standards

Identify questions and concepts that guide scientific investigations. Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations. (Page 175)

Design and conduct scientific investigations. Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations. (Page 175)

Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories. (Page 176)

Benchmarks

Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (Page 13)

Alaska Science Key Element B3

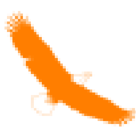
A student who meets the content standard should understand that scientific inquiry often involves different ways of thinking, curiosity and the exploration of multiple paths.

Performance Standard Level 4, Ages 15–18

Students conduct research and media searches that highlight forms of inquiry and multiple solutions to complex problems.

Sample Assessment Ideas

- Students read recent scientific research and reviews of that research to examine suggestions for improvement.
- Local students conduct independent parallel investigations with a student team in a different location on the same research question, compare results, and discuss the processes used to arrive at their respective conclusions.



Expanded Sample Assessment

- Students use primary and secondary research to determine an ideal method of tanning salmon skins in their locality and describe how they arrived at that result.

Procedure

Students will:

1. Investigate salmon skin tanning, including reasons for tanning, why skins and hides are tanned, and traditional and modern methods of tanning.
2. Brainstorm about types of information that might be useful in solving the problem.
3. Divide into small groups to investigate the problem from different perspectives (conduct experiments with skins and hides, interview Elders and professional tanners, research Internet).
4. Share the research results with each other, critique each method of tanning, and develop alternative methods of tanning.

Reflection and Revision

Reflect on ways in which collaboration, creativity, multiple paths of exploration, and personal integrity helped to solve the problem.

Level of Performance

Stage 4 — Student work is complete, correct and shows evidence of elaboration and extension. Student uses multiple sources to identify reasonable solutions to the tanning task including Internet research, and local interviews; designed controlled, quantitative experiments.

Stage 3 — Student work is generally complete, correct and shows some evidence of elaboration and extension. Student uses multiple sources to identify solutions to the tanning task including Internet research and local interviews. Although experimentation is included, it may be poorly controlled, lack quantitative measurements or result in a questionable solution to the tanning task.

Stage 2 — Student work is generally on task but shows little evidence of elaboration. Student may use one or two sources to identify solutions to the tanning task. Although experimentation is included, controls and measurements are lacking.

Solutions, if included, may not be related to the experimental procedure presented.

Stage 1 Student work may be related to tanning but is not targeted to identify multiple solutions to the tanning task. Experiments and use of outside information sources, if included, may not be appropriate or useful.

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and models. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations. (Page 175)

Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists. (Page 176)

Benchmarks

Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others. (Page 287)

Level 4

Alaska Science Key Element B4

A student who meets the content standard should understand that personal integrity, skepticism, openness to new ideas, creativity, collaborative effort, and logical reasoning are all aspects of scientific inquiry.

Performance Standard Level 4, Ages 15–18

Students work in collaborative groups to collect and analyze their experimental results. They conduct media searches and use the information to support their experimental design or experimental evidence.

Sample Assessment Ideas

- Students locate sources of drinking water; test the quality of the water (salinity, pH, turbidity, lead content, microorganism presence, taste); develop a rating scale for potability; and share their methods and results.
- Students determine the energy content of different foods using experimental calorimetric methods. They compare their results to published standards.

Standards Cross-References

National Science Education Standards

Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. (Page 176)

Benchmarks

Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others. (Page 287)

View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive. (Page 287)

Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it. (Page 300)

Level 4

Alaska Science Key Element B5

A student who meets the content standard should employ ethical standards, including unbiased data collection and factual reporting of results.

Performance Standard Level 4, Ages 15–18

Students discuss the validity of assertions made in primary and secondary scientific sources by analyzing and critiquing the data used as evidence to support those assertions.

Sample Assessment Ideas

- Students research whether or not President Thomas Jefferson's descendants include African American descendants of Sally Hemmings, and critique the research used to generate the data that supports both pro and con assertions.
- Students critique the research used to support pro and con arguments in debates regarding quality of life issues (e.g., plastic vs paper, fluoridation of drinking water, use of mercury in dental fillings). Special attention should be given to validity and reproducibility.

Standards Cross-References

National Science Education Standards

Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation. (Page 176)

Scientists have ethical traditions. Scientists value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers. (Page 200)

Benchmarks

Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias. (Page 13)

Current ethics in science hold that research involving human subjects may be conducted only with the informed consent of the subjects, even if this constraint limits some kinds of potentially important research or influences the results. When it comes to participation in research that could pose risks to society, most scientists believe that a decision to participate or not is a matter of personal ethics rather than professional ethics. (Page 19)

Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests. (Page 19)

Notice and criticize arguments based on the faulty, incomplete, or misleading use of numbers, such as in instances when (1) average results are reported, but not the amount of variation around the average, (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend . . . "), (3) absolute and proportional quantities are mixed (as in "3,400 more robberies in our city last year, whereas other cities had an increase of less than 1%), or (4) results are reported with overstated precision (as in representing 13 out of 19 students as 68.42%). (Page 300)

Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly. (Page 300)

Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken, whether one's own or that of others, can be judged. (Page 300)

Alaska Science Key Element B6

A student who meets the content standard should employ strict adherence to safety procedures in conducting scientific investigations

Performance Standard Level 4, Ages 15–18

Students examine laboratory and community safety procedures, identify how an individual affects the safety of the group, and practice safe behavior in the classroom and laboratory.

Sample Assessment Ideas

- Students review the risks associated with medical wastes, and accurately identify the hazards of contaminated fomites.
- Students demonstrate proper techniques of lab safety while determining properties of four unknown, clear, colorless liquids (pH, conductivity, flammability, odor).

Standards Cross-References

National Science Education Standards

Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards. (Page 197)

Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations. (Page 199)

Benchmarks

Benefits and costs of proposed choices include consequences that are long-term as well as short-term, and indirect as well as direct. The more remote the consequences of a personal or social decision, the harder it usually is to take them into account in considering alternatives. But benefits and costs may be difficult to estimate. (Page 166)

Social trade-offs are often generational. The costs of benefits received by one generation may fall on subsequent generations. Also, the cost of a social trade-off is sometimes borne by one generation although the benefits are enjoyed by their descendants. (Page 166)

Alaska Science Content Standard C

Level 1, Ages 15–18

A student should understand the nature and history of science.

Level 4

Alaska Science Key Element C1

A student who meets the content standard should know how the words "fact," "observation," "concept," "principle," "law," and "theory" are generally used in the scientific community.

Performance Standard Level 4, Ages 15–18

Students can differentiate among facts, observations, concepts, principles, laws, and theories, as used in science publications.

Sample Assessment Ideas

- Students define and give examples of the terms commonly used in the scientific community; differentiate how those same terms are defined and used in a non-scientific setting.
- Students analyze a newspaper or magazine article on a science topic, identifying facts, concepts, laws and theories.

Standards Cross-References

National Science Education Standards

Communicate and defend a scientific argument. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments. (Page 176)

Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world. (Page 201)

Benchmarks

Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere. The rules may range from very simple to extremely complex, but scientists operate on the belief that the rules can be discovered by careful, systematic study. (Page 8)

No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a wider range of observations. In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions. (Page 8)

Level 4

Alaska Science Key Element C2

A student who meets the content standard should understand that scientific knowledge is validated by specific experiments that conclude in similar results

Performance Standard Level 4, Ages 15–18

Students evaluate the validity of experimental findings

Sample Assessment Ideas

- Students critique the research used to support pro and con arguments in debates regarding quality of life issues (e.g., plastic vs paper, fluoridations of drinking water, use of mercury in dental fillings). Special attention should be given to validity and reproducibility.
- Students investigate research done by the Department of Fish and Game or Federal biologists on predicted salmon runs. Students compare data and conclusions with previous years' predictions and actual runs.

Standards Cross-Reference

National Science Education Standards

Recognize and analyze alternative explanations and models. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations. (Page 175)

Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation. (Page 176)

Benchmarks

Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in design of their investigations and in their data analysis. Checking each other's results and explanations helps but that is no guarantee against bias. (Page 13)

Wonder how likely it is that some event of interest might have occurred just by chance. (Page 300)

Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one's own or that of others'—can be judged. (Page 300)

Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs, and criticize those in which major trade-offs are not acknowledged. (Page 300) for further investigation. (Page 176)

Level 4

Alaska Science Key Element C3

A student who meets the content standard should understand that society, culture, history, and environment affect the development of scientific knowledge

Performance Standard Level 4, Ages 15–18

Students describe how human society, culture, history, and environment have influenced the development of scientific thinking.

Sample Assessment Ideas

- Students prepare reports on instances where society has repressed scientific knowledge or instances where it has supported and encouraged scientific knowledge (e.g., Galileo, Chinese Cultural Revolution, the National Science Foundation).
- Students prepare reports on instances in Alaska where society has influenced the gathering or use of scientific information, indentifying the influences and their outcome (e.g., the C. Thompson Study).

Standards Cross-Reference

National Science Education Standards

Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology. (Page 199)

Scientists are influenced by the societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society. (Page 201)

In history, diverse cultures have contributed scientific knowledge and technologic inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non-Western cultures. However, other non-European cultures have developed scientific ideas and solved human problems through technology. (Page 201)

Benchmarks

The early Egyptian, Greek, Chinese, Hindu, and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions. (Page 19)

Modern science is based on traditions of thought that came together in Europe about 500 years ago. People from all cultures now contribute to the tradition. (Page 19)

Progress in science and invention depends heavily on what else is happening in society, and history often depends on scientific and technological developments. (Page 19)

Level 4

Alaska Science Key Element C4

A student who meets the content standard should understand that some personal and societal beliefs accept non-scientific methods for validating knowledge

Performance Standard Level 4, Ages 15–18

Students investigate societal (non-scientific) beliefs of multiple communities or cultures regarding a phenomenon.

Sample Assessment Ideas

- Students use multiple sources (oral and written histories, contact with classrooms, and cultures around the world) to compile various beliefs.
- Students discuss the possible origin of each belief.

Standards Cross-Reference

National Science Education Standards

Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism as scientists strive for the best possible explanations about the natural world. (Page 201)

Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful an socially relevant, but they are not scientific. (Page 201)

Because all science ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding is incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. (Page 201)

The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge. (Page 204)

Benchmarks

Cultural beliefs strongly influence the values and behavior of the people who grow up in the culture, often without their being fully aware of it. Response to these influences varies among individuals. (Page 156)

Level 4

Alaska Science Key Element C5

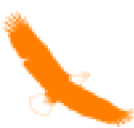
A student who meets the content standard should understand that sharing scientific discoveries is important to influencing individuals and society and in advancing scientific knowledge.

Performance Standard C5, Level 4 Ages 15–18

Students use personal and group experiences as well as media searches to synthesize data derived from multiple perspectives to study a multifaceted problem related to state, regional, or global concerns and post their results for review.

Sample Assessment Ideas

- Students estimate the carrying capacity of a township (or given area); teams make land-use maps of traditional or existing uses; identify and predict the effects of human impact; publish the results for township comment.
- Students use a forum to discuss whether the global climate is changing due to the greenhouse effect, or if recent climate variations are part of normal long-term phenomena. (Students utilize research data when expressing their point of view.)



Expanded Sample Assessment Idea

- Students collect information about landfill; design an improved landfill appropriate for their locale; present their designs to the local planning commission.

Procedure

Student group will

1. Collect information about their local landfill.
2. Research landfill designs in other communities
3. Discuss the current landfill in terms of location, use, type of material in landfill, and how long it will take to fill it.
4. Design a landfill appropriate for their locale. Facts to be considered include porosity and permeability of the soil, interpretation of aerial images (if available), type of material landfill will hold, calculations required to determine landfill size, location of new site and cost consideration.
5. Present their suggested designs to the local planning commission.

Reflection and Revision

Use the planning commission response to revise landfill design.

Level of Performance

Stage 4	Landfill design and justification documents are complete, detailed and show evidence of elaboration, extension, higher-order thinking skills and relevant knowledge.
Stage 3	Landfill design and justification documents are complete and clearly expressed although minor inaccuracies, omissions or inappropriateness may also be evident.
Stage 2	Landfill design and justification documents may contain some elements of proficient work but may be incomplete, inaccurate, or inappropriate for the locale.
Stage 1	Landfill design is incomplete, inaccurate or inappropriate for the locale. Justification documents, if included, lack detail and contain little evidence of relevant knowledge.

Standards Cross-References

National Science Education Standards

Communicate and defend a scientific argument. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments. (Page 176)

Results of scientific inquiry-new knowledge and methods-emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation. (Page 176)

Scientists have ethical traditions. Scientists value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers. (Page 200)

Usually changes in science occur as small modifications in extant knowledge. The daily work of science and engineering results in incremental advances in our understanding of the world and our ability to meet human needs and aspirations. Much can be learned about the internal workings of science and the nature of science from study of individual scientists, their daily work, and their efforts to advance scientific knowledge in their area of study. (Page 201)

Benchmarks

Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but that is no guarantee against bias. (Page 13)

New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators. (Page 13)

Level 4

Alaska Science Key Element C6

A student who meets the content standard should understand that scientific discovery is often a combination of an accidental happening and observation by a knowledgeable person with an open mind.

Performance Standard Level 4, Ages 15–18

Students describe how current research is changing accepted scientific theories.

Sample Assessment Ideas

- Students use a forum to discuss current ideas about the transmission of communicable diseases.
- Students conduct an Internet search on a recent scientific discovery (e.g., development of a new drug treatment, in-utero surgery, genetic engineering) and its effect on current scientific practice.

Standards Cross-References

National Science Education Standards

Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research. (Page 192)

Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. (Page 192)

Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. (Page 201)

Benchmarks

There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic, and good arguments. And there is agreement that progress in all fields of science depends on intelligence, hard work, imagination, and even chance. (Page 13)

New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators. (Page 13)

Level 4

Alaska Science Key Element C7

A student who meets the content standard should understand that major scientific breakthroughs may link large amounts of knowledge, build upon the contributions of many scientists, and cross different lines of study.

Performance Standard Level 4, Ages 15–18

Students identify the research, contributions, discoveries, and collaborative efforts currently underway to solve a scientific, industrial, mechanical, agricultural, or medical problem.

Sample Assessment Ideas

- Students use the Internet and other research tools to compare and contrast how different nations and cultures are responding to the population crisis around the world (e.g., area of declining population, overpopulation, an aging population, etc.).
- Students present the findings of the Human Genome Project; discuss uses for the new information.

Standards Cross-References

National Science Education Standards

Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world. (Page 192)

Occasionally, there are advances in science and technology that have important and long lasting effects on science and society. Examples of such advances include the following: Copernican revolution, Newtonian mechanics, relativity, geologic time scale, plate tectonics, atomic theory, nuclear physics, biological evolution, germ theory, industrial revolution, molecular biology, information and communication, quantum theory, galactic universe, medical and health technology. (Page 204)

Benchmarks

From time to time, major shifts occur in the scientific view of how the world works. More often however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science. (Page 8)

New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators. (Page 13)

Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some sub-disciplines spin off to become new disciplines in their own right. (Page 19)

Alaska Science Key Element C8

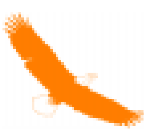
A student who meets the content standard should understand that acceptance of a new idea depends upon supporting evidence and that new ideas that conflict with beliefs or common sense are often resisted.

Performance Standard Level 4, Ages 15–18

Students analyze the evidence used to support current or historic scientific understanding on an issue as well as the evidence used to support ideas contrary to current scientific understanding.

Sample Assessment Ideas

- Students analyze the evidence, pro and con, that the HIV virus causes AIDS.
- Students analyze the evidence that supports and refutes the idea that the first peoples of the Western Hemisphere arrived via a frozen Bering Sea land bridge



Expanded Sample Assessment Idea

- Students choose a commonly held traditional belief that may cause resistance to scientific evidence. Defend a point of view that respects that belief while maintaining an open mind toward scientific evidence.

Procedure

Students will:

1. Choose and research traditional beliefs about the natural world.
2. Share and discuss ideas in pairs or small groups.
3. Do research about the scientific evidence regarding the phenomenon.
4. Write a paper to defend a point of view about the belief.

Reflection and Revision

Modify viewpoint to incorporate anticipated scientific studies.

Level of Performance

Stage 4 — Student demonstrates extensive understanding of traditional beliefs, societal viewpoints and scientific evidence regarding a phenomenon of the natural world. Student defends a position and maintains an open mind toward the opposing evidence or belief.

Stage 3 — Student demonstrates a clear understanding of traditional beliefs, societal viewpoints and scientific evidence regarding a phenomenon of the natural world. Student defends a position but may choose to ignore certain aspects of the opposing evidence or belief.

Stage 2 — Student demonstrates an understanding of traditional beliefs, societal viewpoints or scientific evidence regarding a phenomenon of the natural world. Student defends a position but ignores or belittles the opposing evidence or belief.

Stage 1 — Student demonstrates a limited understanding of traditional beliefs, societal viewpoints or scientific evidence regarding a phenomenon of the natural world. Student defense of a position lacks detail and contains errors and misconceptions regarding the evidence or beliefs.

Standards Cross-References

National Science Education Standards

Recognize and analyze alternative explanations and models. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations. (Page 175)

Communicate and defend a scientific argument. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments. (Page 176)

Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. (Page 176)

Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society. (Page 201)

Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. (Page 201)

Benchmarks

No matter how well one theory fits observations, a new theory might fit them just as well or better, or might fit a broader range of observations. In science, the testing, revising, and the occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth. Evidence for the value of this approach is given by the improving ability of scientists to offer reliable explanations and make accurate predictions. (Page 8)

In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings. (Page 13)

New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators. (Page 13)

Alaska Science Content Standard D

Level 1, Ages 15–18

A student should be able to apply scientific knowledge and skills to make reasoned decisions about the use of science and scientific innovations.

Level 4

Alaska Science Key Element D1

A student who meets the content standard should apply scientific knowledge and skills to understand issues and everyday events.

Performance Standard Level 4, Ages 15–18

Students investigate a regional or global issue; identify and evaluate the current solutions

Sample Assessment Ideas

- Students study parasitic infection affecting food stuffs (e.g., moose, caribou, wheat, rye, peanuts); assess methods for eradication of the parasite.
- Students research oil exploration in Alaska and across the globe; compare the different methods

Standards Cross-References

National Science Education Standards

Formulate and revise scientific explanations and models using logic and evidence. Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical. In the process of answering the questions, the students should engage in discussions and arguments that result in the revision of their explanations. These discussions should be based on scientific knowledge, the use of logic, and evidence from their investigation. (Page 175)

Recognize and analyze alternative explanations and models. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations. (Page 175)

Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. (Page 176)

Benchmarks

Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests. (Page 19)

Level 4

Alaska Science Key Element D2

A student who meets the content standard should understand that scientific innovations may affect our economy, safety, environment, health, and society and that these effects may be short-term or long-term, positive or negative, and expected or unexpected.

Performance Standard Level 4, Ages 15–18

Students research a current problem and conduct a cost and benefit analysis associated with both the problem and potential solutions.

Sample Assessment Ideas

- Students look back on the Y2K issue, and evaluate the impact of the two-digit date on some aspect of our lives.
- Students evaluate the potential positive and negative consequences of recombinant genetics (gene-splicing) in food organisms.

Expanded Sample Assessment Idea

- Students study the risks associated with nuclear power reactors and evaluate various safety, clean-up and waste storage strategies.

Procedure

Students will:

1. Use primary and secondary sources to research safety at several nuclear power facilities (including Chernobyl, Three Mile Island, and plants with no history of mishaps).
2. Evaluate the merits of current safety, clean-up and waste-storage strategies.
3. Compile and share their findings.
4. Independently adopt a waste storage strategy and defend their position in a class discussion.

Reflection and Revision

Revise their position based on arguments from other class members.

Level of Performance

Stage 4 Student uses both primary and secondary sources in researching nuclear power facilities. Student waste storage strategy shows evidence of higher-order thinking and is elaborate.

Stage 3 Student uses either primary or secondary sources in researching nuclear power facilities. Student waste storage strategy shows limited evidence of elaboration or higher-order thinking and may contain minor errors or inaccuracies.

Stage 2 Student uses minimal information to research nuclear power facilities. Student waste storage strategy is incomplete and may show errors to scientific fact, inaccuracies or misconceptions.

Stage 1 Student relies on previous knowledge or biased opinions to collect information about nuclear power facilities. The storage strategy lacks adequate detail and shows evidence of serious misconceptions.

Standards Cross-References

National Science Education Standards

Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national or global challenges. (Page 199)

Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?" (Page 199)

Benchmarks

Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like. (Page 47)

In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits. What alternative ways are there to achieve the same ends, and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs, do they change over time, and who bears them? What are the risks associated with using (or not using) the new technology, how serious are they, and who is in jeopardy? What human, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of and at what costs? (Page 57)

Level 4

Alaska Science Key Element D3

A student who meets the content standard should recommend solutions to everyday problems by applying scientific knowledge and skills.

Performance Standard Level 4, Ages 15–18

Students conduct independent research investigations about a community issue and propose a solution based on their original data.

Sample Assessment Ideas

- Students research the issues involved with commercial fishing bycatch and design possible solutions.
- Students examine and quantify the "daily trash accumulation" for the school; calculate the mass and volume of recyclable and non-recyclable materials. Determine the economic feasibility of creating separate waste repositories.

Standards Cross-References

National Science Education Standards

Identify a problem or design an opportunity. Students should be able to identify new problems or needs and propose ways to change and improve current technological designs. (Page 192)

Propose designs and choose between alternative solutions. Students should demonstrate thoughtful planning for a piece of technology or technique. Students should be introduced to the roles of models and simulations in these processes. (Page 192)

Implement a proposed design. A variety of skills can be needed in proposing a solution depending on the type of technology that is involved. The construction of artifacts can require the skills of cutting, shaping, treating, and joining common materials such as wood, metal, plastics, and textiles. Solutions can also be implemented using computer software. (Page 192)

Evaluate the solution and its consequences. Students should test any solution against the needs and criteria it was designed to meet. At this stage, new criteria not originally considered may be reviewed. (Page 192)

Benchmarks

In designing a device or process, thought should be given as to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The costs associated with these functions may introduce yet more constraints on the design. (Page 52)

Alaska Science Key Element D4

A student who meets the content standard should evaluate the scientific and social merits of solutions to everyday problems

Performance Standard Level 4, Ages 15–18

Students evaluate scientific and societal impacts of developing technologies

Sample Assessment Ideas

- Students evaluate the impact of a developing technology (e.g., new or smaller computers, nanotechnology, self-guided vehicles, Global Positioning System in vehicles, cellular communication devices, fetal surgery, genetic manipulation of plant genomes, cloning).
- Students evaluate the issues surrounding organ transplant with regard to minority populations

Standards Cross-References

National Science Education Standards

Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world. (Page 192)

Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the Earth. (Page 198)

Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change. (Page 199)

Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and accuracy with which scientists and engineers can (and cannot) predict events are important considerations. (Page 199)

Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national or global challenges. (Page 199)

Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology. (Page 199)

Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions: "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?" (Page 199)

Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use which decreases space available to other species—and pollution—which changes the chemical composition of air, soil, and water. (Page 199)

Benchmarks

In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits. What alternative ways are there to achieve the same ends, and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs, do they change over time, and who bears them? What are the risks associated with using (or not using) the new technology, how serious are they, and who is in jeopardy? What human, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of, and at what costs? (Page 57)

Human inventiveness has brought new risks as well as improvements to human existence. (Page 57)

Level 4

Alaska Science Key Element D5

A student who meets the content standard should participate in reasoned discussions of public policy related to scientific innovation and proposed technological solutions to problems.

Performance Standard Level 4, Ages 15–18

Students propose a scientifically or technologically based change to public policy at the local, state, or national level and share their proposal with an audience of those affected by the issue as well as those involved in policy-making decisions.

Sample Assessment Ideas

- Students monitor and suggest ways to improve the water quality in and around their locale.
- Students research and discuss new technologies and the ethics of genetic engineering with other students via the Internet; conduct a class debate on the issue; and write a letter to the National Institute of Health on their position.

Standards Cross-References

National Science Education Standards

Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms—sensory, motor, emotional, social, and technological—that can reduce and modify hazards. (Page 197)

Materials from human societies affect both physical and chemical cycles of the Earth. (Page 198)

Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the Earth. (Page 198)

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Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use which decreases space available to other species, and pollution, which changes the chemical composition of air, soil, and water. (Page 199)

Benchmarks

In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits. What alternative ways are there to achieve the same ends, and how do the alternatives compare to the plan being put forward? Who benefits and who suffers? What are the financial and social costs, do they change over time, and who bears them? What are the risks associated with using (or not using) the new technology, how serious are they and who is in jeopardy? What human, material, and energy resources will be needed to build, install, operate, maintain, and replace the new technology, and where will they come from? How will the new technology and its waste products be disposed of and at what costs? (Page 57)

The human species has a major impact on other species in many ways: reducing the amount of the Earth's surface available to those other species; interfering with their food sources, changing the temperature and chemical composition of their habitats; introducing foreign species into their ecosystems; and altering organisms directly through selective breeding and genetic engineering. (Page 57)

Humans inventiveness has brought new risks as well as improvements to human existence. (Page 57)

Level 4

Alaska Science Key Element D6

A student who meets the content standard should act upon reasoned decisions and evaluate the effectiveness of the action.

Performance Standard Level 4, Ages 15–18

Students work collaboratively to design a solution to a problem, develop an evaluation tool to measure the effectiveness of their solution, and make revisions to the original solution based on the information collected.

Sample Assessment Ideas

- Students identify the greatest sources of physical injury in the community; design a public awareness program for lowering risks, evaluate the result after informing the public
- Students examine various shampoos; evaluate which one works the best with the local water supply.

Standards Cross-References

National Science Education Standards

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Implement a proposed design. A variety of skills can be needed in proposing a solution depending on the type of technology that is involved. The construction of artifacts can require the skills of cutting, shaping, treating, and joining common materials (eg., wood, metal, plastics, and textiles). Solutions can also be implemented using computer software. (Page 192)

Evaluate the solution and its consequences. Students should test any solution against the needs and criteria it was designed to meet. At this stage, new criteria not originally considered may be reviewed. (Page 192)

Benchmarks

Social and economic forces strongly influence which technologies will be developed and used. Which will prevail is affected by many factors, such as personal values, consumer acceptance, patent laws, the availability of risk capital, the federal budget, local and national regulations, media attention, economic competition, and tax incentives. (Page 57)

Human inventiveness has brought new risks as well as improvements to human existence. (Page 57)