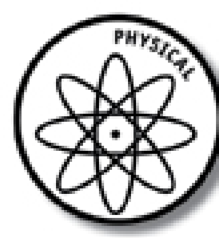
Translating Standards to Practice

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

LEVEL 3, Ages 11–14



Translating Standards to Practice

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

LEVEL 3

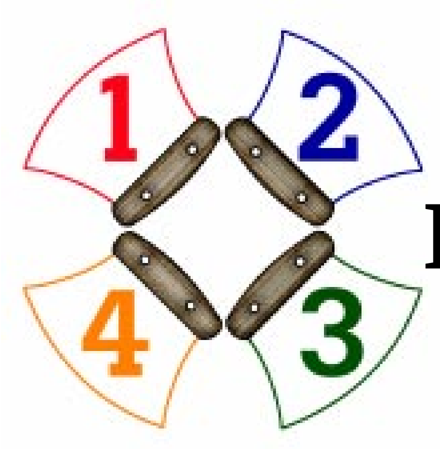
Developed collaboratively by the Alaska State Department of Education & Early Development and the Alaska Rural Systemic Initiative with funding provided by the National Science Foundation.

Published by the:

Alaska Native Knowledge Network
University of Alaska Fairbanks
PO Box 756730
Fairbanks, Alaska 99775-6730

www.ankn.uaf.edu

First printing November 2000. Permission to reproduce for educational purposes.



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.

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.

Acknowledgments

Performance Standards Writing Team

Kipi Asicksik
Bering Straits School District

Gary Bender
Fairbanks North Star
Borough School District

Linnea Burmeister
Nome City Schools

Lisa Buttry-Thomas
University of Alaska Fairbanks

Cheryl Cooper
Delta/Greely School District

Peggy Cowan
Juneau School District

Cynthia Curran
Matanuska-Susitna Borough
School District

Alan Dick
Alaska Rural Systemic Initiative

Dolly Garza
University of Alaska

David Gillam
Anchorage School District

Leslie Gordon
Fairbanks North Star Borough School District

Stephanie Hoag
Science and Mathematics Consortium For Northwest
Schools

Steven Jacquier
Southwest Region School District

Leona Kitchens
Alaska Rural Systemic Initiative

Bob Nanney
Anchorage School District

Harry Oyoumick
Bering Straits School District

Gail Raymond
Anchorage School District

Daniel Solie
University of Alaska Fairbanks

Sidney Stephens
University of Alaska Fairbanks

Amy Van Hatten
Alaska Rural Systemic Initiative

Donna York
Anchorage School District

Performance Standards Committee

Bernadette Alvanna-Stimpfle
Nome City Schools

Linnea Burmeister
Nome City Schools

Nancy Douglas
Juneau School District

Robin Dublin
Alaska Department of Fish and Game
Project Wild

Judy Hurlburt
Anchorage Public Schools

Esther Ilutsik
University of Alaska Fairbanks
Bristol Bay Campus

Elmer Jackson
Alaska Rural Systemic Initiative

Sharon John
Anchorage School District

Charles Kashatok
Lower Kuskokwim School District

Oscar Kawagley
Alaska Rural Systemic Initiative

Jackie Kookesh
Chatham School District

Angie Lunda
Juneau Borough School District

Chip McMillan
University of Alaska Fairbanks

Roger Norris-Tull
University of Alaska Fairbanks
Bristol Bay Campus

Rita O'Brien
Fairbanks North Star Borough School District

John Petersen
Fairbanks North Star Borough
School District

Larry Read
Independent Consultant

Margie Revet
Lower Kuskokwim School District

Thelma Saunders
Fairbanks North Star Borough School District

Cole Schaeffer
Cominco Alaska
Red Dog Mine

Roger Trottier
North Slope Borough Schools

Alaska Rural Systemic Initiative

Ray Barnhardt
Co-Director

Frank Hill
Co-Director

Oscar Kawagley
Co-Director

Dorothy Larson
Co-Director

Moses Dirks
Aleutian/Alutiiq Regional Coordinator

Leona Kitchens
Aleutian/Alutiiq Regional Coordinator

Teri Schneider
Aleutian/Alutiiq Regional Coordinator

Amy Van Hatten
Athabascan Regional Coordinator

Elmer Jackson
Inupiaq Regional Coordinator

Andy Hope
Southeast Regional Coordinator

Barbara Liu
Yupik Regional Coordinator

Alan Dick
Village Science Coordinator

Claudette Bradley
AISES Coordinator

Editing and Production

Megan Martin, Consultant
Science Education and Assessment

Patty Kreikemeier
Independent Consultant

Lisiana Hinojosa
SRI International

Paula Elmes
Alaska Native Knowledge Network

Sheri Gray
University of Alaska Southeast

Len Peterson
University of Alaska Southeast

Yeong Lu
University of Alaska Southeast

State Board of Education & Early Development Members

Susan Stitham, Chair
Lathrop High School

Roy Nageak
First Vice Chair

Mike P. Williams
Second Vice Chair

Lieutenant Colonel Mark Avery
Military Advisor

Jacob Fuller Student Advisor
Dimond High School

Paula Pawlowski

Ernie Hall

Sally Rue

Alaska Department of Education & Early Development

Richard S. Cross
Commissioner

Bruce Johnson
Deputy Commissioner

Barbara Thompson
Deputy Director

Cynthia Curran
Science Specialist

Performance Standard Review Teams

Anchorage

Barbara Bodnar
ADNR Division of Forestry

Traci Caves
Anchorage School District

Helen Cole
Matanuska-Susitna Borough
School District

Janice Heinrich
Building a Presence for Science

Trisha Herminghaus
C & I Science
Anchorage School District

Judy Hurlburt
C & I Science
Anchorage School District

Mia Jackson
The Imaginarium

Leona Kitchens
Alaska Rural Systemic Initiative

Peggy Kristich
Matanuska-Susitna Borough School District

Melody Mann
Matanuska-Susitna Borough School District

Naomi Mayer
Pacific Northern Academy

Ted Munsch
Alaska Pacific University

Harry O'Brien
USDA Natural Resources Conservation Service

Gail Raymond
Anchorage School District

Guy Sandlin
Lower Yukon School District

Donna Gail Shaw
University of Alaska Anchorage
School of Education

Emma Walton
National Science Teachers Association

Donna York
Anchorage School District

Fairbanks

Lisa Buttry-Thomas
University of Alaska Fairbanks

Jeff Drake
Geophysical Institute
University of Alaska Fairbanks

Lawrence Duffy
Institute of Arctic Biology—UAF

Linda Evans
Alaska Native Knowledge Network

Chip McMillan
University of Alaska Fairbanks
School of Education

John Morack
University of Alaska Fairbanks
Physics Department

Martha Robus Kopplin
Partners in Science
Fairbanks North Star Borough School District

John Peterson
University of Alaska Fairbanks

Carol Scott
North Pole Leadership Academy

Daniel Solie
University of Alaska Fairbanks

Elena Sparrow
University of Alaska Fairbanks
Plant, Animal & Soil Sciences Department

Performance Standard Review Teams, con't.

Juneau

Patty Brown
Haines Borough School District

Annie Calkins
Juneau School District

Charlotte Candalaria
Sitka Borough School District

Pat Harris
Auke Bay Lab

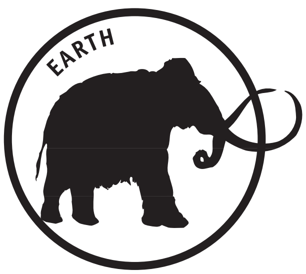
Stephanie Hoag
Science and Mathematics Consortium for Northwest Schools

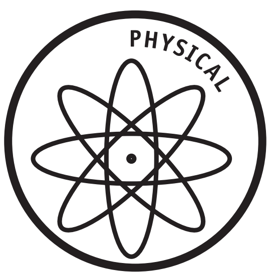
Jody Marcello
Sitka School District

Joe Marcello
Sheldon Jackson College

Carolyn Mork
Sitka Borough Schools

Ernie Selig
Alyeska Central School





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

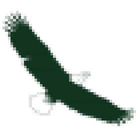
A student who meets the content standard should understand models describing the nature of molecules, atoms, and sub-atomic particles and the relation of the models to the structure and behavior of matter.

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 for 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)

Level 3

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)

Level 3

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 Earth's 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 earth’s 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.
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 changes.
5. Discuss how different large-scale motions of the earth’s interior produce different landforms on the earth’s surface.

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.

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 earth 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 the 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)

Level 3

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 of 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)

Alaska Science
Key Element A8b

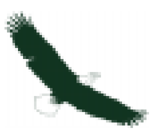
A student who meets the content standard should understand the scientific principles and models that state whenever energy is reduced in one place, it is increased somewhere else by the same amount (Energy Transformations).

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

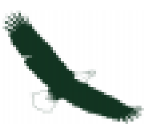
A student who meets the content standard should understand the scientific principles and models that state that whenever there is a transformation of energy, some energy is spent in ways that make it unavailable for use (Energy Transformations).

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)

Alaska Science
Key Element A9

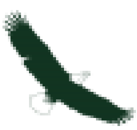
A student who meets the content standard should understand the transfers and transformations of matter and energy that link living things and their physical environment from molecules to ecosystems (Flow of Matter and Energy).

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)

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)

Level 3

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)

Level 3

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)

Alaska Science Key Element A14a

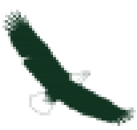
A student who meets the content standard should understand the interdependence between living things and their environments (Interdependence).

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)

Alaska Science Key Element A14b

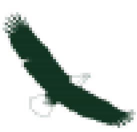
A student who meets the content standard should understand that the living environment consists of individuals, populations, and communities (Interdependence).

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)

Level 3

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

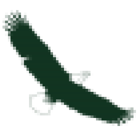
A student who meets the content standard should use science to understand and describe the local environment (Local Knowledge).

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.

Level 3

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 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)

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)

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 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 group's 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)

Level 3

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)

Level 3

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.

Level 3

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)

Level 3

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)

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 beliefs 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 beliefs 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.

Level 3

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)

Alaska Science Key Element D2

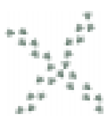
A student who meets the content standard should understand that scientific innovations may affect our economy, safety, environment, health, and society and that these effects may be short-term or long-term, positive or negative, and expected or unexpected.

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

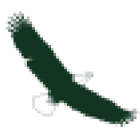
A student who meets the content standard should recommend solutions to everyday problems by applying scientific knowledge and skills.

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 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 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 student's 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 student's 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 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)

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 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)

Level 3

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)

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 for 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)