North Dakota

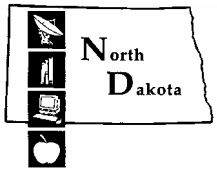
Standards and Benchmarks

Content Standards

Science

November 2002

North Dakota Department of Public Instruction
Dr. Wayne G. Sanstead, State Superintendent
600 E Boulevard Avenue, Dept. 201
Bismarck, North Dakota 58505-0440
www.dpi.state.nd.us



The work in this publication is funded wholly or in part by grants from the Elementary and Secondary Education Act, Title II, U.S. Department of Education. Its contents do not necessarily reflect the views or policies of the Department, or any other agency of the U.S. Government.

PROJECT DIRECTOR
Clarence A. Bina, Ph.D.
School Improvement, Assistant Director
North Dakota Department of Public Instruction
600 East Boulevard Avenue - 9th Floor
Bismarck, North Dakota 58505-0440
Phone: 701-326-2098
Email: cbina@mail.dpi.state.nd.us

CONSULTANT (2001, 2002)
Carolyn R. Brauner, Ph.D.
Educational Consulting
2115 2nd Place NE
Jamestown, ND 58401
Phone: 701-252-5289
Email: cbrauner@jc.edu

PREVIOUS CONSULTANTS (1997-2000)
Ceri B. Dean
Deb Jordan
Mid-continent Research for Education and Learning
Aurora, CO

North Dakota Science Content and Achievement Standards Writing Team (2002)

(This team revised some of the N.D. Science Content Standards and Benchmarks ©2001 upon review during their writing of the N.D. Science Achievement Standards.)

Carol Beaton, M.S.
Fargo South High School
Fargo

John Brauner, Ph.D.
Jamestown College
Jamestown

Mike Burton
Discovery Jr. High
Fargo

Rita Charlebois, M.Ed.
Bismarck Public
Mandan

Maxine Foss
Leeds Public School
Leeds

Mary Gleason
Dakota Prairie High School
Petersburg

Mark Gonzalez, Ph.D.
North Dakota Geological Survey
Bismarck

Gary Jackson, M.Ed.
Valley
Hoople/Crystal

Michelle Keller, M.Ed.
Bisbee-Egeland High
Bisbee

Mary Kester
Burlington/Des Lacs Elementary at United #7
Burlington

Cy Kotaska
Sawyer Public
Sawyer

Judith Krueger
Enderlin Public
Enderlin

Ila LaChapelle
Walhalla High School
Walhalla

Robbi Jo Morgan
Roosevelt School
Minot

Sheryl Nesseth, M.Ed.
Century Elementary
Grand Forks

Susan Syverson
Washington Elementary
Jamestown

Pamela Thompson, M.Ed.
West Fargo High
Fargo

Elizabeth (Betty) Ussatis, M.Ed.
Washington Elementary
Valley City

Rae Ann Vandrovec
St. John's Academy
Jamestown

Mike Watterson, M.Ed.
Valley City Junior High
Valley City

North Dakota Science Content Standards Writing Team (1997-2001)

Angie Bartholomay
Bottineau High School
Bottineau

Clarence (Gene) Bender
Dunseith High School/ Minot State University – Bottineau, Dunseith/Bottineau

Carolyn R. Brauner, Ph.D.
Education, Valley City State University
Valley City

John F. Brauner, Ph.D.
Biology, Jamestown College
Jamestown

Mike Burton
Discovery Junior High
Fargo

Rita Charlebois
Northridge Elementary
Bismarck

Maxine Foss
Leeds Public School
Leeds

Kathryn Froelich
Sitting Bull College
Forte Yates

Mark A. Gonzalez, Ph.D.
Geologist, North Dakota Geological Survey
Bismarck

Melanie Kathrein, M.Ed.
Dickinson High School
Dickinson

Michelle R. Keller, M.Ed.
Bisbee-Egeland High School
Bisbee

Ellen Knudson
Solheim Elementary School
Bismarck

Cy Kotaska
Sawyer High School
Sawyer

Ila LaChapelle
Hope Public School
Hope

Gerald Roth, Ed.D.
Education, University of Mary
Bismarck

Elizabeth (Betty) Ussatis, M.Ed.
Washington Elementary School
Valley City

Neil Westergaard, M.S.
Chemistry, Williston State College
Williston

Don Yellowbird
White Shield School
Roseglen

Revisions Made for this 2002 Edition

	OLD - 2001 version	NEW - 2002 version
Introduction This statement is inserted at the end of Paragraph 4. **Components of the Document** This statement is inserted into Examples of Specific Knowledge section.		Teachers are encouraged to refer to *The National Science Education Standards* (1996) and the *Benchmarks for Science Literacy* (1993)(from Project 2061) for explanations of the concepts listed in the Examples of Specific Knowledge sections of this document.
Under **Standard 1** **-** Grades 4, 8, 12	Benchmark 4.1.5, 8.1.5 Understand the relationship between form and function. 12.1.5 Understand relationships between form and function.	Benchmarks 4.1.5, 8.1.5 & 12.1.5 Understand relations between form and function
- Grade 4 (Insert "in" before position)	Benchmark 4.1.3 Understand that changes might occur in properties of materials and position and motion of objects.	Benchmark 4.1.3 Understand that changes might occur in properties of materials and in position and motion of objects
- Grade 12	Benchmark 12.1.2 Understand how scientists create and use hypothetical structures or simplified models.	12.1.2 Understand how scientists create and use models
- Grade 12	Benchmark 12.1.3 Understand relationships between constancy and change.	Benchmark 12.1.3 Understand concepts of constancy and change
Under **Standard 2** - Grade 4	Benchmark 4.2.5 Know that scientific investigations are reviewed by other scientists before they are made public.	Benchmark 4.2.5 Review scientific investigations done by others as scientists do.
- Grade 8	Benchmark 8.2.7 Communicate scientific procedures, explanations, results, and conclusions in a variety of ways.	Benchmark 8.2.7 Communicate the aspects of a scientific investigation in a variety of ways.

Under **Standard 3** - Grade 8	Benchmark 8.3.1 Understand properties of matter and how they relate to physical and chemical changes in matter.	Benchmark 8.3.1 Understand properties of matter and their relations to physical and chemical changes in matter
	Benchmark 8.3.2 Understand the relationship between force and motion.	Benchmark 8.3.2 Understand relations between force and motion
- Grade 12	Benchmark 12.3.1 Understand the structure of atoms.	Benchmark 12.3.1 Understand the structure and behavior of atoms
Under **Standard 4** **-** Grade 4	Benchmark 4.4.3 Understand the relationships between organisms and environments.	Benchmark 4.4.3 Understand relations between organisms and environments.
	Benchmark 4.4.4 Understand how changes in life forms have occurred over time.	Benchmark 4.4.4 Know that changes in life forms have occurred over time
- Grade 8	Benchmark 8.4.1 Understand relationships between structure and function in living systems.	Benchmark 8.4.1 Understand relations between structure and function in living systems
	Benchmark 8.4.3 Understand the importance of regulation and behavior of organisms.	Benchmark 8.4.3 Understand regulation in and behavior of organisms
- Grade 12	Benchmark 12.4.2 Understand the development of systems from simple to complex organisms.	Benchmark 12.4.2 Understand how systems and organisms develop through the differentiation of cells
- Grade 12 - **Specific Knowledge** sections - (move “Classification, taxonomy” from 12.4.2 to 12.4.4) - (In 12.4.2, after Levels of organization add “functions of cells”; remove () and ie; add “comparisons among diverse organisms”)	Specific Knowledge... 12.4.2 Classification, taxonomy, levels of organization, specialization of cells (i.e., organelles, tissues, organs) 12.4.4 Adaptation, mutation, natural selection, speciation, species change through time, extinction, differential reproduction	Specific Knowledge... 12.4.2 Levels of organization; functions of cells; specialization of cells, organelles, tissues, organs; comparisons among diverse organisms 12.4.4 Classification, taxonomy, adaptation, mutation, natural selection, speciation, species change through time, extinction, differential reproduction
- Grade 12	Benchmark 12.4.6 Understand the role of matter, energy, and organization in living systems.	Benchmark 12.4.6 Understand the role of matter and energy in the organization of living systems

Standard 5: (**All grades**)	*Students understand the basic concepts and principles of Earth and space science.*	***Students understand the basic concepts and principles of earth and space science.***
- Grade 4 (change "Earth" to "earth")	Benchmark 4.5.1 Know the properties and uses of Earth materials.	4.5.1 Know the properties and uses of earth materials.
(remove "the")	Benchmark 4.5.3 Know ways that changes occur in the Earth's surface and atmosphere	Benchmark 4.5.3 Know ways that changes occur in Earth's surface and atmosphere
Under **Standard 5** - Grade 8 (change "of the Earth" to "of Earth")	Benchmarks 8.5.1-8.5.4	Benchmark 8.5.1 Understand the structure and processes of Earth. 8.5.2 Understand landforms and the processes that change the surface of Earth. 8.5.3 Understand the types of evidence used to reconstruct the history of Earth and the evolution of life. 8.5.4 Understand the structure and processes of Earth's atmosphere.
- Grade 12 (change "Earth" to "earth")	Benchmark 12.5.1	12.5.1 Understand the origin and evolution of the earth system.
- Under **Specific Knowledge** Change "radiometicage" to "radiometric age"	Specific Knowledge 12.5.1 radiometicage	radiometric age
(change "between" to "among")	Benchmark 12.5.4	12.5.4 Understand the interactions among the geosphere, hydrosphere, atmosphere, and biosphere.
Standard 6 (**All grades**)	*Students understand connections and relationships between science and technology.*	***Students understand relations between science and technology.***
- Grade 12	Benchmark 12.6.3 Understand how technology affects the present and future.	Benchmark 12.6.3 Understand how scientific and technological developments interact and produce consequences.

Standard 7 (**All grades**)	*Students understand the relationship of science to personal, social, and environmental issues.*	***Students understand relations between science and personal, social, and environmental issues.***
- Grade 12	Benchmark 12.7.1 Understand how science relates to personal and community health issues.	Benchmark 12.7.1 Understand relations between science and personal and community health issues
- Grade 8 (insert hyphen between "human induced")	Benchmark 8.7.3	Benchmark 8.7.3 Understand the challenges presented to the individual and society by human-induced hazards.
(remove ", now and in the future"	Benchmark 8.7.5	Benchmark 8.7.5 Understand the limitations of science and technology in dealing with social issues.

TABLE OF CONTENTS

Components of the Document

Content Standards – general statements that describe what students should know and the skills they should have in a specific content area

Benchmarks – statements of knowledge and skill that define a standard at a given developmental level (e.g., 4th grade, 8th grade, 12th grade)

Examples of Specific Knowledge – facts, vocabulary, principles, generalizations, relations, concepts, step-by-step procedures, strategies, or processes that are the specific information or skills that students should acquire to meet a standard
(Teachers are encouraged to refer to *The National Science Education Standards* (1996) and the *Benchmarks for Science Literacy* (1993) (from Project 2061) for explanations of the concepts listed in the Examples of Specific Knowledge sections of this document.

Examples of Activities – instructional activities that students could do to acquire the knowledge and skills described in the standard and benchmarks

**Indicates the word or phrase is defined in the Glossary*

Introduction

Development of the Document
The science content standards for the state of North Dakota were developed during 1997-2001 by a team of educators, kindergarten through higher education, working with representatives from both the Department of Public Instruction and the Mid-continent Regional Educational Laboratory. The initial efforts to write the science standards began in 1992. The current document was based partially upon that work, and to a larger extent, on the *National Science Education Standards* published in 1996 by the National Academy of Sciences.

Purpose
The purpose of the state science standards is to provide school boards, administrators, educators, and parents with a guide to develop K-12 science curriculum at the consortium and district level. The state science standards document is not intended to serve as a handbook or text, but rather to be a guide for aligning curricular content, objectives, and outcomes. The standards document provides the audience with sources of information and examples of activities to meet the science standards.

Organization of the Document
This document defines **eight science content standards** that outline what students should know, understand, and be able to do in the natural sciences. Each standard is further described through benchmarks, examples of specific knowledge, and sample activities. The benchmarks, specific knowledge, and sample activities are written for three grade ranges: K-4, 5-8, and 9-12. The standards in this document are content standards. They indicate the knowledge that a student knows or understands and the skills he or she performs by the end of grades 4, 8, and 12 in a specific content area – in this case, science. The **standards** and **benchmarks** are written in terms of the **type** of knowledge the student is expected to learn (facts, theories, relations, concepts, generalizations, principles, algorithms, strategies, processes) not in terms of the activities they might engage in to learn the knowledge (e.g., listing, explaining, comparing and contrasting, describing, etc.). The standards do not describe the level of knowledge or understanding or the ways in which students demonstrate their knowledge or understanding.

The section entitled "**Examples of Specific Knowledge that Support the Standards and Benchmarks**," lists skills, concepts, theories, processes, history, technologies, scientific principles, and applications important to knowing and understanding science. The section includes knowledge recommended for student understanding at the end of the appropriate grade levels: 4, 8, and 12. While this section lists specific examples of knowledge to support the standards, the list of examples is by no means exhaustive. Teachers are encouraged to refer to *The National Science Education Standards* (1996) and the *Benchmarks for Science Literacy* (1993) (from Project 2061) for explanations of the concepts listed in the Examples of Specific Knowledge sections of this document.

"Examples of Activities" are suggested activities that support, illustrate, and emphasize the knowledge described by the standards and benchmarks. The activities were selected to provide students with opportunities to develop research skills, to explore applications and roles of science and technologies, to expand problem solving and critical thinking skills, to use the scientific method for problem solving, and to experience science for fun, interest, and life-long learning.

The **Resources** section lists sources for the Sample Activities, contact people, suppliers, support people, and additional activity sources. A **Glossary** provides a list of terms and definitions supporting the document.

**Indicates the word or phrase is defined in the Glossary*

Goals for Science Education in North Dakota

Science education standards for the state of North Dakota give guidelines for the development of curriculum by each school system. These guidelines reflect important educational reforms taking place across the nation. Teachers in North Dakota see the need for reform efforts, including a shift toward inquiry-based learning, use of technology, integration among the sciences and with other disciplines, and unification of the approach to science across grades K-12. The following goals for science education reflect reform efforts and are intended for all students.

All students will:

- experience the richness and excitement of knowing about and understanding the natural world;
- be able to inquire about and investigate the natural and technological world;
- develop an understanding of and ability to use processes of science;
- communicate intelligently on topics of scientific and technological concern;
- use creativity, problem-solving skills, and decision-making strategies to make personal and professional decisions;
- increase their economic productivity through the use of knowledge, understanding, and skills of the scientifically literate person in their careers;
- develop an appreciation and respect for the natural world.

Advancements in science and technology have affected every aspect of our society, increasing the need for developing a more scientifically literate society. Science provides information and develops problem-solving skills. It helps us make informed decisions, understand processes in nature, appreciate and respect the natural world, and use technology comfortably. It helps develop a skilled, competent workforce. Science affects the quality of life. We hope these standards help all students understand and benefit from science.

**Indicates the word or phrase is defined in the Glossary*

North Dakota Science Content Standards

Standard 1: UNIFYING CONCEPTS
Students understand unifying concepts and processes of science.

Standard 2: SCIENCE INQUIRY
Students use the process of science inquiry.

Standard 3: PHYSICAL SCIENCE
Students understand the basic concepts and principles of physical science.

Standard 4: LIFE SCIENCE
Students understand the basic concepts and principles of life science.

Standard 5: EARTH AND SPACE SCIENCE
Students understand the basic concepts and principles of earth and space science.

Standard 6: SCIENCE AND TECHNOLOGY*
Students understand relations between science and technology*.

Standard 7: SCIENCE AND OTHER AREAS
Students understand relations between science and personal, social, and environmental issues.

Standard 8: HISTORY AND NATURE OF SCIENCE*
Students understand the history and nature of science*.

** - indicates the word or phrase is included in the Glossary*

Summary of Grades K-4 Standards and Benchmarks

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

4.1.1 Understand that a system is made up of parts that work together
4.1.2 Understand that models help explain objects and ideas
4.1.3 Understand that changes might occur in properties of materials and in position and motion of objects
4.1.4 Understand that change might occur in order to maintain balance in a system
4.1.5 Understand relations between form and function

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

4.2.1 Use and integrate the science processes of observing, questioning, hypothesizing and reflecting to investigate their world
4.2.2 Use simple scientific tools to gather information
4.2.3 Plan and conduct controlled investigations
4.2.4 Keep records of their investigations and share their results with others as scientists do
4.2.5 Review scientific investigations done by others as scientists do

Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

4.3.1 Know properties of objects and materials
4.3.2 Know that position and motion of objects can be described and changed
4.3.3 Know characteristics of light, heat, electricity, and magnetism

Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

4.4.1 Understand characteristics of organisms
4.4.2 Know the characteristics of the life cycle of organisms
4.4.3 Understand relations between organisms and environments*
4.4.4 Know that changes in life forms have occurred over time

Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

4.5.1 Know the properties and uses of earth materials
4.5.2 Know the names and basic characteristics of celestial objects
4.5.3 Know ways that changes occur in Earth's surface and atmosphere

** - indicates the word or phrase is included in the Glossary*

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

4.6.1 Know the various forms that technology* can take
4.6.2 Understand how natural objects differ from those made by humans
4.6.3 Design technological solutions to a problem
4.6.4 Understand concepts and applications of science and technology

Standard 7: SCIENCE AND OTHER AREA

Students understand relations between science and personal, social, and environmental issues.

4.7.1 Know basic concepts of personal health
4.7.2 Understand characteristics of and changes in populations of organisms
4.7.3 Understand how different types of resources affect our lives
4.7.4 Understand how changes in environments* affect populations of organisms
4.7.5 Understand how culture* influences the way people relate to science

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

4.8.1 Understand how people have used science throughout time
4.8.2 Know basic beliefs and attitudes that scientists share
4.8.3 Understand the role of individuals and cultures in contributing to science

** - indicates the word or phrase is included in the Glossary*

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

Benchmarks

4.1.1 Understand that a system is made up of parts that work together
4.1.2 Understand that models help explain objects and ideas
4.1.3 Understand that changes might occur in properties of materials and in position and motion of objects
4.1.4 Understand that change might occur in order to maintain balance in a system
4.1.5 Understand relations between form and function

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.1.1 Components of some systems (e.g., solar system, body system, and ecosystem)
4.1.2 Models (e.g., toy car, globe), characteristics of a model
4.1.3 Changes in size, weight, color, movement may be slow or fast (e.g., growth of living things, changes in landforms, changes from solids to liquids)
4.1.4 Cause and effect relations (e.g., animal populations, plant populations)
4.1.5 Animal classification, landforms, simple machines

Examples of Activities that Support the Standard and Benchmarks

4.1.1 Students identify parts and functions of the circulatory system. They explain how parts of the circulatory system interact with other body systems.
4.1.2 Working in pairs, students create a model of a space shuttle. (One possible approach is to use food items for the model. Cut a carrot in half for the external fuel tank, use celery sticks - attached with peanut butter to the carrot stick - for the solid rocket boosters, and bread for the orbiter.) Students explain how the model is like and not like the real space shuttle. (A similar activity can be found in *Mission Mathematics: Linking Aerospace and the NCTM Standards, K-6*.)
4.1.3 Students observe a chicken or goose hatching. They draw and record the changes that occur and identify the type of change (i.e. size, weight, etc.).
4.1.4 Students visit a pet shop and observe several aquariums. They participate in a discussion, answering questions such as, “What type of fish are in a well-balanced tank and why?”, “What changes can happen to the tank if it is not balanced?”. They then choose appropriate plants and fish to create a classroom aquarium.
4.1.5 Students create inclined planes of various angles and heights. They explain which is most efficient and why. Then, they identify places where they observe inclined planes and explain their form and function.
4.1.5 Students create models of animals feet using play dough. They compare them to see how and where animals move.

** - indicates the word or phrase is included in the Glossary*

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

Benchmarks

4.2.1 Use and integrate the science processes of observing, questioning, hypothesizing, and reflecting to investigate their world
4.2.2 Use simple scientific tools to gather information
4.2.3 Plan and conduct controlled investigations
4.2.4 Keep records of their investigations and share their results with others as scientists do
4.2.5 Review scientific investigations done by others as scientists do

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.2.1 Questioning techniques (i.e., asking questions, narrowing to a researchable question, comparing and contrasting, probing), importance of scientific attitudes*
4.2.2 Use scientific tools (e.g., thermometers, magnifiers, rulers, balances, eye droppers, microscopes, slides)
4.2.3 Investigation design (i.e., data collection, observation, model, experiment, invention)
4.2.4 Ways to keep records (e.g., journals, drawings, charts), ways to share information (i.e., speaking, writing, and listening)
4.2.5 Criteria scientists use to review work of other scientists (i.e., use of a control, appropriate number of samples, and trials to establish validity; evaluate methods used)

Examples of Activities that Support the Standard and Benchmarks

4.2.1 Students conduct an experiment to compare different brands of paper towels in terms of cost, absorption, and texture. Based on investigation results, students determine a personal preference.
4.2.2 Students use an eyedropper to discover how many drops of water can be dropped on a penny before it overflows. They explain why there may be variations in the number of drops.
4.2.3 With teacher guidance, students plan an investigation manipulating one variable. For example, they might grow several plants under the same conditions except for the amount of light. (Half of the plants could be grown in light and half in no light). Students record their observations over a period of time and graph and discuss the results of the experiment
4.2.4 Students take turns bringing living and non-living objects into the classroom. With the teacher's help, students create a chart that states what they know and what they want to know about living and non-living objects. Students choose one question to investigate and present their results as a Science Showcase.
4.2.5 Students, working in groups, answer the question, "How much force is needed to lift a load?" They use a ruler as a lever and two pencils as a fulcrum. They put cups on each end of the ruler (one as the force cup, one as the load cup) and place two washers in the load cup. Students add washers to the force cup until the load is lifted. They check another group's controls and use of samples and trials.

** - indicates the word or phrase is included in the Glossary*

Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

Benchmarks

4.3.1 Know properties of objects and materials
4.3.2 Know that position and motion of objects can be described and changed
4.3.3 Know characteristics of light, heat, electricity, and magnetism

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.3.1 Objects have many observable properties (e.g., size, weight, shape, color, temperature) and the ability to react with other substances; objects are made of one or more materials (e.g., paper, wood, metal); materials can exist in different states (i.e., solid, liquid, and gas); conservation of matter

4.3.2 Objects are located relative to other objects (e.g. further than, beside, under, over); positions change by push and pull; objects may have motion (e.g. straight, circular, and back-and-forth); pitch of sound depends on frequency of vibrations

4.3.3 Light travels; definition of reflection, refraction, and absorption; heat is produced by burning, rubbing, or mixing substances; heat movement (i.e., conduction); electricity in circuits; magnets attract and repel

Examples of Activities that Support the Standard and Benchmarks

4.3.1 Students classify buttons according to properties (e.g., color, size, and weight). Students graph results and summarize differences.

4.3.2 Students are given a tuning fork and a glass of water. They strike the fork on their knee and quickly place the tuning fork in water. They observe and record the results and use them to discuss the impact of the vibrations on the water.

4.3.3 Students are given a set of materials and predict which materials will be attracted, repelled, or unaffected by a magnet. Then they conduct an experiment to confirm or reject their predictions. Finally, students assemble a different set of materials and exchange the set with another group. Based on the results of their first experiment, they predict the results for the new set of materials.

** - indicates the word or phrase is included in the Glossary*

Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

Benchmarks

4.4.1 Understand characteristics of organisms
4.4.2 Know the characteristics of the life cycle of organisms
4.4.3 Understand relations between organisms and environments*
4.4.4 Know that changes in life forms have occurred over time

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.4.1 All living things have basic needs in order to survive (i.e., water, air, nutrients, light); plants and animals have different structures for different functions in growth, survival, and reproduction; behavior influenced by internal cues (e.g., hunger) and external cues (e.g., a change in the environment)
4.4.2 All living things go through stages of development, reproduction, and death; inherited characteristics and learned* characteristics; plants and animals closely resemble their parents
4.4.3 All animals depend on plants; food chains, food webs; animal and plant patterns of behavior are related to the nature of their environment; organisms, including humans, cause changes in their environments* that can be beneficial or detrimental
4.4.4 Changes in structure and functions (e.g., past to present-day buffalo), differences in organisms (e.g., types of dogs) having a common ancestor, fossil records

Examples of Activities that Support the Standard and Benchmarks

4.4.1 Students conduct an experiment with plants to determine the effects of soil, water, and light. Students observe plants receiving just light, no water, and plants receiving water, no light. They create a graph over a period of time to explain their observations of survival.
4.4.2 Students compare the young and adult of different animals and insects to see if their appearances are similar or different. (A similar activity, “Are You Me?” can found in the *Project Wild/Aquatic* materials.)
4.4.3 Using pictures of three different types of bears in their natural environment, students identify similarities and differences (e.g., their habitats, adaptations for survival). [Similar activities, “What Bear Goes Where?” and “What’s for Dinner?” can be found in the *Project Wild* materials.]
4.4.4 Students analyze a variety of dogs (pictures, videos) and describe their similarities and differences to the wolf noting any changes over time. (Ancestor of domestic dogs was wolf-like.)
4.4.4 Students examine a variety of fossils and describe the similarities and differences between the fossils and related contemporary organisms. They explain how environmental factors may have contributed to the change.

** - indicates the word or phrase is included in the Glossary*

Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

Benchmarks

4.5.1 Know the properties and uses of earth materials
4.5.2 Know the names and basic characteristics of celestial objects
4.5.3 Know ways that changes occur in Earth's surface and atmosphere

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.5.1 Rocks, soils, water, uses of Earth materials (e.g., building materials, sources of fuel, fossil evidence about plants and animals that lived long ago)
4.5.2 Sun, moon, stars, and planets have properties, locations, and movements that can be observed and described over time; the sun provides light and heat
4.5.3 Earth's surface changes (e.g., erosion, landslides, volcanic eruption, earthquakes), atmospheric changes and composition (e.g., wind, temperature, clouds, precipitation); layers of the atmosphere; rock formations

Examples of Activities that Support the Standards and Benchmarks

4.5.1 Students brainstorm different kinds of Earth materials. They choose one material and find several examples of how it is used as they go on a "materials-use" walk.

4.5.2 On a sunny day, students measure and compare the length of their shadow three times during the day (i.e. early morning, mid-day, and late afternoon) at a set location. They explain how the changes in the length of the shadow are related to how the Earth moves in relation to the sun.

4.5.3 Students work in pairs to construct a model that demonstrates the processes of the water cycle. (A resource for an introduction to this activity is the story *The Magic* water cycle. (A resource for an introduction to this activity is the story *The Magic School Bus: At the Waterworks* by Johanna Cole.)

** - indicates the word or phrase is included in the Glossary*

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

Benchmarks

4.6.1 Know the various forms that technology* can take
4.6.2 Distinguish how natural objects differ from those made by humans
4.6.3 Design technological solutions to a problem
4.6.4 Understand concepts and applications of science and technology

Examples of Activities that Support the Standard and Benchmarks

4.6.1 Technological tools (e.g., zippers, Velcro, measuring instruments, computers), definition of technology*
4.6.2 Observe, compare, analyze characteristics of natural (occur in nature) objects and designed (human-made) objects
4.6.3 Steps in solving problems (i.e., identify problem, ask questions, plan a solution, recognize possible constraints, implement, evaluate, and communicate the problem, design, and solution) (design principles*)
4.6.4 Science answers questions and explains the natural world; technology invents tools and develops techniques to assist scientists in investigations and solving human problems; scientists and engineers often work in teams; females and males of various backgrounds do scientific and technological work; the application of science and technology may have positive and negative effects

Examples of Activities that Support the Standard and Benchmarks

4.6.1 Students brainstorm different forms of technology* (e.g., common objects like shoes, pencils, crayons, scissors, eyeglasses, measuring cups and spoons).
4.6.2 Students collect a variety of objects or pictures of objects and classify the objects as natural or human-made (e.g., rock flint vs. a match, bone needle vs. sewing machine, cave home vs. brick home) and provide reasons for their classifications.
4.6.3 Students use a given set of materials to design a container to keep an ice cube from melting. They evaluate the results and share their process and results with their classmates.
4.6.4 Students interview scientists to learn how they work in teams and how technological tools help them make better observations and measurements in their investigations about the natural world.
4.6.4 In the context of discussing the problem of determining where a garden could be planted (e.g., by the school) and which areas have the most/least wind, the students discuss which instruments scientists and engineers have developed to use to help them (wind gauges)
4.6.4 In the context of discussing the problem of determining if enough rainfall exists to grow certain plants (crops, trees, etc.), students discuss what scientists and engineers have designed to measure depth of precipitation (rain gauge). (Same could be done with other weather instruments: thermometers, weather vanes, etc.)

** - indicates the word or phrase is included in the Glossary*

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

Benchmarks

4.7.1 Know basic concepts of personal health
4.7.2 Understand characteristics of and changes in populations of organisms
4.7.3 Understand how different types of resources affect our lives
4.7.4 Understand how changes in environments* affect populations of organisms
4.7.5 Understand how culture* influences the way people relate to science

Examples of Specific Knowledge that Support the Standard and Benchmarks

4.7.1 Cleanliness, dental hygiene, nutrition, exercise, how disease is spread, substance awareness, safety and security
4.7.2 Population density, populations increase unless other factors such as disease or famine decrease the population
4.7.3 Material resources (e.g., air, water, soil, food, fuel, building materials), nonmaterial resources (e.g., quiet places, beauty, security, safety), availability
4.7.4 Natural or human-made environmental changes; change can occur slowly or rapidly
4.7.5 Awareness of and the sensitivity to the effects of culture* on people's attitudes in science; new ideas and inventions; science and technology* have greatly improved food quality and quantity, transportation, health, sanitation, and communication

Examples of Activities that Support the Standard and Benchmarks

4.7.1 Students prepare questions to ask a speaker on personal hygiene. Using the information they learned from the speaker, they write a story (e.g., the travels of a germ beginning with a person's sneeze).
4.7.2 Students observe the playground over a period of time, recording the number of students and the types of interactions among students. They describe the relations they observe. They determine the best place to be on the playground and give the reasons for their choices.
4.7.3 Students discuss the purpose of recycling. They plan and conduct a paper recycling campaign.
4.7.4 Students make a pictorial chart showing the conditions before and after flooding and discuss the effects on human and animal populations.
4.7.5 Students prepare questions about how artifacts found on archeological digs demonstrate the influence of culture* on people's views of science to ask anthropologists or archeologists from a local university, museum, or government agency. (Note: If anthropologists or archeologists are not accessible locally, students could use the Internet to contact people in these positions.) Students may want to ask about how dig procedures are used to preserve scientific artifacts.

** - indicates the word or phrase is included in the Glossary*

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

Benchmarks

4.8.1 Understand how people have used science throughout time
4.8.2 Know basic beliefs and attitudes* that scientists share
4.8.3 Understand the role of individuals and cultures* in contributing to science

Examples of Specific Knowledge that Support the Standard and Benchmark

4.8.1 Investigations increase knowledge of the world, more remains to be understood
4.8.2 Curiosity, open-mindedness, perseverance, objectivity, honesty, willingness to engage in critical thinking, desire for reliable sources of information
4.8.3 Technological inventions and innovations developed by people from diverse backgrounds, people enjoy doing science, science careers

Examples of Activities that Support the Standard and Benchmarks

4.8.1 Students choose different parts of the playground to observe, create questions to discuss, and record their discoveries. They explain how their actions show how people use science as a natural process of inquiry.
4.8.1 Compare and contrast how inventions have changed through time (e.g., eyeglasses, cars, eating utensils).
4.8.2 Students listen to the teacher read *The Value of Believing in Yourself*: *The Story of Louis Pasteur* by Spencer Johnson, M.D. In groups, they discuss the ways in which Pasteur demonstrated the use of scientific attitudes* or processes*.
4.8.2 After reading about or listening to several scientists talk about their work, students prepare a summary of what they have learned about the beliefs and attitudes about science that scientists share.
4.8.3 Students identify tools that man has used for sewing (e.g., needles [awl, sinew, bone, metal, plastic] and thread [sinew, wool, rawhide, cotton, polyester]). They create a timeline that shows when the various tools were used. (Natural medicines also could be identified and how they were discovered.)

** - indicates the word or phrase is included in the Glossary*

Summary of Grades 5-8 Standards and Benchmarks

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

8.1.1 Understand the structure and organization of systems
8.1.2 Understand how models can be used to explain scientific principles
8.1.3 Understand how patterns of change and constancy apply to various systems
8.1.4 Understand how change affects systems in equilibrium
8.1.5 Understand relations between form and function

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

8.2.1 Understand how questions that can be answered by scientific inquiry* differ from those that can not
8.2.2 Design and carry out a scientific investigation
8.2.3 Use appropriate technology* and techniques to gather and interpret data
8.2.4 Use acquired data to develop descriptions, explanations, predictions, and models
8.2.5 Use acquired data and critical analysis to formulate conclusions
8.2.6 Understand that alternative explanations and procedures in scientific inquiry* may exist
8.2.7 Communicate the aspects of a scientific investigation in a variety of ways
8.2.8 Use mathematics in the process of scientific inquiry*

Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

8.3.1 Understand properties of matter and their relations to physical and chemical changes in matter
8.3.2 Understand relations between force and motion
8.3.3 Know the characteristics of various forms of energy and the principles governing energy transformation and transfer

Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

8.4.1 Understand relations between structure and function in living systems
8.4.2 Understand the basic principles governing genetics and reproduction
8.4.3 Understand regulation in and behavior of organisms
8.4.4 Understand the interactions of populations in ecosystems
8.4.5 Understand the cause and significance of diversity and adaptations of organisms

** - indicates the word or phrase is included in the Glossary*

Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

8.5.1 Understand the structure and processes of Earth
8.5.2 Understand landforms and the processes that change the surface of Earth
8.5.3 Understand the types of evidence used to reconstruct the history of Earth and the evolution of life
8.5.4 Understand the structure and processes of Earth's atmosphere
8.5.5 Understand the structure and processes of the oceans
8.5.6 Understand the Theory of Plate Tectonics
8.5.7 Understand the structure and features of our solar system and the universe and the relations between them

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

8.6.1 Design a solution, using science and technology, to a problem related to human needs or wants
8.6.2 Understand how science and technology* are similar and different
8.6.3 Understand the limitations and possibility for unintended outcomes of technological solutions

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

8.7.1 Understand how science influences personal health
8.7.2 Understand how limiting factors* affect populations, resources, and environments*
8.7.3 Understand the challenges presented to the individual and society by human-induced hazards
8.7.4 Use a systematic approach to analyze risks and benefits
8.7.5 Understand the limitations of science and technology in dealing with social issues

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

8.8.1 Understand how science is influenced by human qualities
8.8.2 Understand how scientists' beliefs and attitudes* influence their work.
8.8.3 Understand how science has changed from a historical perspective

** - indicates the word or phrase is included in the Glossary*

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

Benchmarks

8.1.1 Understand the structure and organization of systems
8.1.2 Understand how models can be used to explain scientific principles
8.1.3 Understand how patterns of change and constancy apply to various systems
8.1.4 Understand how change affects systems in equilibrium
8.1.5 Understand relations between form and function

Examples of Specific Knowledge that Support the Standard and Benchmarks.

8.1.1 Systems have components and those components interact; a system has processes; systems are connected to other systems; properties of parts differ from the properties of the whole; boundaries of systems exist
8.1.2 Models take many forms (i.e., device, drawing, equation, computer program, diagram, mental image); models can be used to imitate concepts, features or phenomena
8.1.3 Characteristics of static systems (i.e., nothing is happening), characteristics of dynamic systems (i.e.. change is occurring), examples of static and dynamic systems (e.g., conservation of mass, populations, resources)
8.1.4 Feedback mechanisms (e.g., hunger, perspiring), causes and effects (i.e., stimuli and response), equilibrium, action and reaction
8.1.5 Arrangement of atoms, cell specialization, anatomical structure, shape as related to use

Examples of Activities that Support the Standard and Benchmarks

8.1.1 Students perform actual or virtual dissection of a plant or animal and identify the organ systems. They select other systems from across life, Earth, and physical science, identify the components and or subsystems of each system and explain how the parts and/or subsystems interact.
8.1.2 Students explain the phases of the moon using a model of the moon, sun, and Earth. Students identify other models across the life, Earth, and physical sciences that help to explain scientific principles (e.g., cell model, model of the atom, geologic time table).
8.1.3 Students use the concept of patterns of change and constancy to explain the developmental stages observed during the life cycle of a butterfly. They identify other patterns of change and constancy across life, Earth, and physical science (e.g., rock cycle, water cycle, conservation of energy).
8.1.4 Students use the concept of equilibrium to explain differences in breathing rates, heart rates, and skin temperatures before and after strenuous exercise. Students identify examples of ways in which systems change to maintain balance across life, Earth, and physical science.
8.1.5 Students make inferences about the diet and habitats of various birds based on observations they have made about the form and function of each bird's beak and feet. Students then identify the relationship between the form and function

** - indicates the word or phrase is included in the Glossary*

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

Benchmarks

8.2.1 Understand how questions that can be answered by scientific inquiry* differ from those that can not
8.2.2 Design and carry out a scientific investigation
8.2.3 Use appropriate technology* and techniques to gather and interpret data
8.2.4 Use acquired data to develop descriptions, explanations, predictions, and models
8.2.5 Use acquired data and critical analysis to formulate conclusions
8.2.6 Understand that alternative explanations and procedures in scientific inquiry* may exist
8.2.7 Communicate the aspects of a scientific investigation in a variety of ways
8.2.8 Use mathematics in the process of scientific inquiry*

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.2.1 Criteria needed for a question to be solved scientifically (e.g., testable hypothesis, reproducible results, controlled environment)
8.2.2 Steps of scientific method (e.g., observation skills, data collection, data interpretation, communication of results
8.2.3 Select appropriate tools of science (e.g., microscopes vs. hand lens, graduated cylinder vs. beaker, balance vs. spring scale), use tools appropriately
8.2.4 Graphing, modeling, mathematical equations, characteristics of valid scientific data
8.2.5 Use of experimental data to accept or reject hypotheses, to identify relations, to identify cause and effect, to identify patterns
8.2.6 Problems can be solved in different ways, more than one answer may be acceptable
8.2.7 Writing, speaking, drawing (e.g., journals, lab reports, diagrams, presentations, and discussions)
8.2.8 Basic mathematical operations, measurement, appropriate metric units, accuracy and precision, statistics, estimation

Examples of Activities that Support the Standard and Benchmarks

8.2.1 Given an item (e.g., shoe, rock, flower, pumpkin), students pose a question that could and one that could not be investigated scientifically about the item. From a list of the compiled questions, students determine which questions can be answered through experimentation (e.g., average number of seeds, kinds of minerals in rocks, etc.) and which can not (e.g., which is prettiest, best brand, etc.).
8.2.2 Students are given a paper bag containing 10-15 items. They develop an experiment using the items in the bag and present their experiment to the class.
8.2.3 While using a temperature probe connected to a computer/thermometer, students gather and interpret data to determine the efficiency of insulating material.
8.2.4 Students organize collected data into a graph to show the relationship of fertilizer to plant growth. Students explain what the graph represents and how it can be used to explain the data.
8.2.5 Students determine if the scientific evidence in a summary data chart in *Consumer Reports* substantiates recommendations about the “Best Buy” for a particular purchase.

** - indicates the word or phrase is included in the Glossary*

8.2.6	Students construct a dichotomous key of a group of objects such as leaves, rocks, seashells, or seeds. Students exchange keys with other groups and explain why different keys produce the same results.
8.2.7	Students communicate the results of an experiment or science fair project to the rest of the class. Students use appropriate technology* and communication skills.
8.2.8	Students find the mass of a licorice stick. Given a fictitious half-life of the licorice stick, the students predict the mass of the stick after a given period of time. The students then simulate the breakdown of the stick by tearing the stick into halves. The students compare the final mass to the predicted mass.
8.2.8	Students determine the rate of absorption of heat using a number of variables such as color on outside of can, size of can, type of liquid in can, distance of can from heat source. Students determine which variable most affects temperature change. Students describe applications of the results in their daily lives.

** - indicates the word or phrase is included in the Glossary*

Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

Benchmarks

8.3.1	Understand properties of matter and their relations to physical and chemical changes in matter
8.3.2	Understand relations between force and motion
8.3.3	Know the characteristics of various forms of energy and the principles governing energy transformation and transfer

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.3.1	Characteristics of matter, elements, compounds, mixtures, states of matter, Law of Conservation of Matter, structure of the atom, molecules, density, periodic table, chemical and physical changes
8.3.2	Characteristics of forces (driving and resisting, balanced and unbalanced) and motion; simple and compound machines; gravity, magnetism, friction
8.3.3	Law of Conservation of Energy, forms of energy (kinetic and potential, electrical, chemical, heat, mechanical, light, sound), energy technologies (e.g. generator, batteries, solar panels, circuits, wind turbines)

Examples of Activities that Support the Standard and Benchmarks

8.3.1	Students use ice cubes, water, and steam to explain physical changes. They burn small pieces of paper to demonstrate chemical changes. Students compare physical and chemical changes and explain the properties of matter that determine the type of change.
8.3.2	Students design and construct a vehicle, powered by rubber bands or balloons, that moves a required distance. By varying the amount of force during several trial runs, students compare the interaction between force and motion.
8.3.3	Using wire, a nail, and a battery, students construct an electromagnet and use it to pick up various objects. They experiment to determine what increases the strength of the magnet. Students use the concepts of conservation of energy to explain their observations.

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** - indicates the word or phrase is included in the Glossary*

Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

Benchmarks

8.4.1 Understand relations between structure and function in living systems
8.4.2 Understand the basic principles governing genetics and reproduction
8.4.3 Understand regulation in and behavior of organisms
8.4.4 Understand the interactions of populations in ecosystems
8.4.5 Understand the cause and significance of diversity and adaptations of organisms

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.4.1 Differences between living and nonliving, life activities, parts of a cell, levels of organization, role of disease, photosynthesis, respiration
8.4.2 Life comes from life, genes, chromosomes, asexual and sexual reproduction, parts of a flower, DNA, RNA, mutation
8.4.3 Life span, respiration, excretion, absorption, nutrition, levels of growth, metamorphosis, migration, feeding strategies
8.4.4 Producers and consumers, food web, decomposers, natural cycles, populations, dependence of life on energy (sun, chemical) and matter, resources
8.4.5 Similarity of cells of all organisms, differences between organisms, natural selection, evolution*, extinction, adaptation, speciation, competition

Examples of Activities that Support the Standard and Benchmarks

8.4.1 Students make a cell model using mediums of their choice (e.g., gelatin and fruit cocktail, drawings, and Play-Doh®). They explain how the item selected to represent each part of the cell relates to the function of that part.
8.4.2 Students compare asexual and sexual reproduction by growing and observing yeast budding and by dissecting and identifying parts of a flower.
8.4.3 Students raise *Brassica rapa* (Wisconsin Fast Plants) and other plants for several generations, comparing life cycles and growth rates
8.4.4 Students make a mural showing food web.
8.4.4 Students construct a closed ecosystem (e.g., terrariums, aquariums, “life in a bottle”).
8.4.5 Students select an organism and discuss how the organism has changed over time (e.g., the horse, plant varieties).
8.4.5 Students represent different species capable of eating a particular food resource represented by a type of token. Different tokens represent different food resources. Students take turns acquiring tokens to obtain a minimum number to allow reproduction. At random, infrequent time intervals, the student actively acquiring food draws a card (mutation) allowing access to a different food type which allows increased population. Inability to acquire set minimum amount leads to extinction.

** - indicates the word or phrase is included in the Glossary*

Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

Benchmarks

8.5.1 Understand the structure and processes of Earth
8.5.2 Understand landforms and the processes that change the surface of Earth
8.5.3 Understand the types of evidence used to reconstruct the history of Earth and the evolution of life
8.5.4 Understand the structure and processes of Earth's atmosphere
8.5.5 Understand the structure and processes of the oceans
8.5.6 Understand the Theory of Plate Tectonics
8.5.7 Understand the structure and features of our solar system and the universe and the relations between them

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.5.1 Layers of Earth, crustal plates (lithosphere and asthenosphere), oceanic versus continental crust, mantle, core, convection, subduction, mountain building (orogenesis), isostasy, earthquakes, plate motion, three rock types (sedimentary, igneous, metamorphic) and the Rock Cycle
8.5.2 Landforms (e.g., flood plain, terrace, moraine, beach, mountain, volcanoes), faults, erosion, deposition, weathering (chemical and mechanical), running water, ice, wind, gravity, crustal deformation, volcanic eruption; soil and soil formation; water cycle
8.5.3 Radioactivity, radioactive decay, and radiometric dating; formation and preservation of fossils, the fossil record, extinction and evolution of life forms; climate change, laws of superposition and original horizontality, cross-cutting relations
8.5.4 Layers of the atmosphere, evaporation, condensation, formation and types of clouds, solar energy transfer in the atmosphere, weather patterns and systems, weather forecasting, climate, storms, water cycle
8.5.5 Ocean water properties (i.e., density, thermal layers, salinity, mineral content), tides, currents, depth, pressure changes, life forms, features of the ocean floor, ocean resources
8.5.6 Plate tectonics, crustal plates, lithosphere, mantle, oceanic and continental plates, plate motion and velocity, subduction, earthquakes, volcanic eruptions, mountain building (orogeny), convection, sea-floor spreading, types of plate boundaries (convergent, divergent, and transform)
8.5.7 Characteristics of our solar system (e.g., relative size, position, and movements of sun and planets); solar energy, radiation; planetary features, other objects in the solar system (e.g., asteroids, comets, meteors); interrelations of Earth, moon, and sun (i.e., seasons, tides, eclipses, phases of the moon, length of year and day); gravity, orbit, revolution, universe; galaxies; stars; Big Bang Theory; Doppler effect, light speed

** - indicates the word or phrase is included in the Glossary*

Examples of Activities that Support the Standard and Benchmarks

8.5.1 Students use the Internet to obtain recent data regarding earthquake and volcanic activity. Students plot the data on a world map to determine patterns and relate this to plate tectonics.

8.5.2 Students observe and compare the similarities and differences between fossils and modern life forms.

8.5.3 Students visit local museum and speak with paleontologist to see the evolution of life in the fossil record.

8.5.4 Student/instructor recreate water cycle to demonstrate evaporation and condensation.

8.5.5 Students create a layered ocean (hot water over cold water (indicated by food coloring) and then study how wind (hair dryer) creates ocean circulation patterns.

8.5.6 Use Slinky®, ropes, tuning forks, and/or wave machines to create waves. Describe the motion and property of the various waves. Determine which media (solid, liquid, gas) transmit different types of waves. Relate this information to the study of the interior of the earth and the propagation of P- and S-waves.

8.5.6 Compare and contrast the geologic processes and features that typify convergent, divergent, and transform plate boundaries.

8.5.7 Students construct and use scaled physical models of the solar system to demonstrate size, position relations, seasons, tides, etc. Students record and graph the changes in the length of day, the time of sunrise and sunset, and the phases of the moon to understand the orbits of the earth around the sun and the moon about the earth..

** - indicates the word or phrase is included in the Glossary*

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

Benchmarks

8.6.1	Design a solution, using science and technology, to a problem related to human needs or wants
8.6.2	Understand how science and technology* are similar and different
8.6.3	Understand the limitations and possibility for unintended outcomes of technological solutions

Examples of Specific Knowledge that Support the Standard and Benchmarks.

8.6.1	Design principles*; choice and use of appropriate technological tools and measurements, cooperative learning skills, calculation of cost and profit, critical thinking skills, technology* assisted communication skills to explain their design
8.6.2	Science explores the natural world; technology* seeks solutions to human problems and needs; science drives technology*; technological solutions are temporary
8.6.3	Limitations of technology* (e.g., design constraints, cost, time, tradeoffs, pollution, safety, efficiency), cause and effect

Examples of Activities that Support the Standard and Benchmarks

8.6.1	Students work in cooperative groups on a toothpick (or spaghetti) bridge building project. Each student has a specific job (e.g., engineer, project manager, etc.). They must work within a budget, adhere to ta time frame, and evaluate the finished bridge with weight bearing tests. See also “Pucker effect” in Project WET guide.
8.6.2	Students perform three different dilutions using a spoon, an eyedropper, and a micropipet as the measuring tools. Each tool represents an advancement in technology*. The solution is a 1:10 red food coloring and is diluted with water. Students dilute the solution 1:100, 1:1000, 1:1,000,000 by mixing one part of the previous solution and compare their results to those of other groups. They discuss the ways in which the results are similar and different and explain why.
8.6.3	Students compare the weekly weather forecasts with actual weather. They discuss the limitations of science and technology in forecasting and how the limitations affect our lives.

** - indicates the word or phrase is included in the Glossary*

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

Benchmarks

8.7.1	Understand how science influences personal health
8.7.2	Understand how limiting factors* affect populations, resources, and environments*
8.7.3	Understand the challenges presented to the individual and society by human-induced hazards
8.7.4	Use a systematic approach to analyze risks and benefits
8.7.5	Understand the limitations of science and technology in dealing with social issues

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.7.1	Injury prevention, disease immunization, organ transplants, medical tools (e.g., CAT scan, X-rays), synthetic materials, food technology* (e.g., preservatives, flavor enhancers, meat inspection, packaging)
8.7.2	Overpopulation, natural hazards (e.g., earthquakes, storms, floods), conservation, recycling, pollution control, local conservation needs or concerns
8.7.3	Disasters may impact the quality of life (e.g., no food, water, shelter, electricity; loss of life, destruction of property, fear)
8.7.4	Steps of scientific process*, cause and effect relations
8.7.5	Medical (e.g., spinal cord injuries), natural disasters, ethical issues

Examples of Activities that Support the Standard and Benchmarks

8.7.1	Students compare flavor, ingredients, texture, and mold resistance of homemade or bakery bread and a brand name bread. They list how advancements of science have influenced bread making. (This activity may be extended to other foods.)
8.7.2	Students role-play the carrying capacity of a habitat for a deer population over a period of several years based on deer population numbers and available resources (i.e. food, water, shelter, and space). (A similar activity, "Oh Deer," can be found in the *Project Wild* materials.)
8.7.3	Students participate in a role-playing activity to illustrate human impact on the environment. (A recommended activity would be "Where Are the Frogs?" from the *Project WET* materials. This activity shows how acidic water has endangered the lives of aquatic organisms and their ecosystems.)
8.7.4	Given a map that includes rivers, commercial areas, and a volcano, students select a building site for a home. They communicate the reasoning behind their site selection based on the potential risks and benefits of their choices to themselves, society, and the environment.
8.7.5	Students write essays that describe a futuristic society where human cloning is common.

** - indicates the word or phrase is included in the Glossary*

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

Benchmarks

8.8.1	Understand how science is influenced by human qualities
8.8.2	Understand how scientists' beliefs and attitudes* influence their work
8.8.3	Understand how science has changed from a historical perspective

Examples of Specific Knowledge that Support the Standard and Benchmarks

8.8.1	Human qualities, e.g., reasoning, insightful, skill, creativity, life-long learning
8.8.2	Scientists share traits (e.g., skepticism, optimism, curiosity, persistence, open-mindedness, tentative); ethical standards
8.8.3	Cultural beliefs and contributions; individual contributions; scientific advancements may lead to more advancements; cultures* both restrict and contribute to science

Examples of Activities that Support the Standard and Benchmarks

8.8.1	Students write a diary of an imaginary journey with the Lewis and Clark Expedition. They include details of their food supply, food preparation, medicine, shelter and travel mode. They compare such a journey with a similar journey taken today with the advantages of scientific advancements.
8.8.2	Students collect stories of reported UFO sightings from video, Internet, or newspaper sources. They role-play, simulate, or discuss the beliefs and attitudes that scientists hold about such sightings. Employ traits that scientists share.
8.8.3	Students construct a timeline that traces important advancements in science through history.

** - indicates the word or phrase is included in the Glossary*

Summary of Grades 9-12 Standards and Benchmarks

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

12.1.1 Understand the structure, organization, and dynamics of systems
12.1.2 Understand how scientists create and use models
12.1.3 Understand concepts of constancy and change
12.1.4 Understand principles governing evolution* and equilibrium within systems
12.1.5 Understand relations between form and function

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

12.2.1 Identify problems, develop appropriate questions, and recognize relevant concepts that guide scientific investigations
12.2.2 Design and conduct investigations in various ways to solve problems in a variety of forms
12.2.3 Use appropriate measuring systems and tools
12.2.4 Collect, organize, analyze, and use data to solve problems
12.2.5 Formulate conclusions based upon experimental data
12.2.6 Identify and analyze alternative explanations to scientific problems
12.2.7 Use knowledge and skills from other academic disciplines to solve problems in science
12.2.8 Use various forms of communication to present results and explanations of scientific investigations

Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

12.3.1 Understand the structure and behavior of atoms
12.3.2 Understand the structure, composition, and properties of matter
12.3.3 Understand the characteristics of chemical reactions
12.3.4 Understand the principles and relations influencing forces and motion
12.3.5 Understand the properties and behaviors of waves
12.3.6 Understand the Law of Conservation of Energy and its implications
12.3.7 Understand interactions of energy and matter

Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

12.4.1 Understand the structure and function of cells and their components
12.4.2 Understand how systems and organisms develop through the differentiation of cells
12.4.3 Understand the molecular basis of heredity
12.4.4 Understand the theory of biological evolution

** - indicates the word or phrase is included in the Glossary*

12.4.5 Understand the interdependence of organisms and their environments*
12.4.6 Understand the role of matter and energy in the organization of living systems

Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

12.5.1 Understand the origin and evolution of the earth system
12.5.2 Understand the origin and evolution of the universe
12.5.3 Understand the principles governing energy and its transfer in the earth system
12.5.4 Understand the interactions among the geosphere, hydrosphere, atmosphere, and biosphere
12.5.5 Understand the effects that geologic processes and human activities can have on the environment

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

12.6.1 Understand the role of technology* in applying scientific knowledge to meet human needs and wants
12.6.2 Use technological design to solve a problem or to improve current technology*
12.6.3 Understand how scientific and technological developments interact and produce consequences

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

12.7.1 Understand relations between science and personal and community health issues
12.7.2 Understand the principles governing change and how change affects the environment and quality of life
12.7.3 Understand how natural resources are affected by social and environmental issues and variables
12.7.4 Understand components of and issues affecting environmental quality
12.7.5 Understand the role of science and technology* in addressing local, national, and global challenges
12.7.6 Understand how science and technology* influence personal, industrial, and cultural decision making

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

12.8.1 Understand how cultural elements and intellectual perspectives have influenced the development of science throughout history
12.8.2 Understand the nature of scientific knowledge
12.8.3 Understand how human characteristics influence scientific advancement
12.8.4 Understand the role of science and scientists in theoretical and applied situations

** - indicates the word or phrase is included in the Glossary*

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

Benchmarks

12.1.1	Understand the structure, organization, and dynamics of systems
12.1.2	Understand how scientists create and use models
12.1.3	Understand concepts of constancy and change
12.1.4	Understand principles governing evolution* and equilibrium within systems
12.1.5	Understand relations between form and function

Examples of Specific Knowledge that Support the Standard and Benchmarks

12.1.1	Components and interactions of a system
12.1.2	Hypothesis, model, law, principle, theory, paradigm
12.1.3	Patterns and cycles in nature, predictions based on patterns/cycles
12.1.4	Cause/effect (plate tectonics/volcanism and earthquakes, disease/population change, temperature and pressure change/gas volume); diversity within systems affects stability, adaptations, ecological succession, positive and negative feedback
12.1.5	Physical, chemical and biological structures determine characteristics and function (conductors vs. nonconductors, polar vs. nonpolar molecules, energy efficiency of organisms and materials, cell specialization), classification based on form and function

Examples of Activities that Support the Standard and Benchmarks.

12.1.1	Students select a system (e.g., computer or networking system, body system, heating system, ecological system), identify its components, and explain how the components work together.
12.1.2	Students select a theory or hypothesis, develop a model that represents that theory/hypothesis, and explain to the class the value of the theory or hypothesis.
12.1.3	Students take a field trip to a cemetery to collect data comparing the dates of death to the ages of the individuals at their time of death in pre and post war era. They research and hypothesize explanations for the patterns found. (A similar activity, "Lives of Soap Bubbles and People," can be found in *TIMS* materials.)
12.1.4	Students, working in pairs, are given two large containers with different amounts of water; each container is not more than half full. Each student is given a smaller container which is a different size than his or her partner's container. Students transfer the water from their large container to their partner's large container using their small container until equilibrium is reached in the large containers. (A similar activity, "Let the Transfer Begin," can be found in *CRISTAL* materials.)
12.1.5	Students develop a dichotomous key based upon structure and function (e.g., trees, birds' beaks and feet, fish, insects).

** - indicates the word or phrase is included in the Glossary*

Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry

Benchmarks

12.2.1	Identify problems, develop appropriate questions, and recognize relevant concepts that guide scientific investigations
12.2.2	Design and conduct investigations in various ways to solve problems in a variety of forms
12.2.3	Use appropriate measuring systems and tools
12.2.4	Collect, organize, analyze, and use data to solve problems
12.2.5	Formulate conclusions based upon experimental data
12.2.6	Identify and analyze alternative explanations to scientific problems
12.2.7	Use knowledge and skills from other academic disciplines to solve problems in science
12.2.8	Use various forms of communication to present results and explanations of scientific investigations

Examples of Specific Knowledge that Support the Standard and Benchmarks

12.2.1	Process for conducting a literature search and formulating a testable hypothesis
12.2.2	Use of appropriate technologies, safety procedures, mathematical and communication skills; identification of independent and dependent variables; use of controls while conducting an investigation
12.2.3	Selection and appropriate use of instruments, measuring tools, and measuring systems including metric
12.2.4	Construction of appropriate data tables, charts, and graphs; data interpretation, interpolation, and extrapolation; use of significant figures and correct units of measure; use of factor-label method (i.e., dimensional analysis)
12.2.5	Recognition and calculation of error, evaluation of hypothesis, formulation of conclusion
12.2.6	Use multiple sources (e.g., journals, Internet, lab group data) to find and compare information, weigh evidence, examine logic
12.2.7	Recognize the integration of disciplines (e.g., writing technical papers, basic algebra skills, reading comprehension, computer skills)
12.2.8	Proper communication skills, computer applications, multi-media communication (e.g., oral reports, term papers, spreadsheet(s)

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Examples of Activities that Support the Standard and Benchmarks

12.2.1	Students are given a current event problem. In cooperative groups, they conduct a literature search and attempt to formulate a solution to the problem using scientific investigation. They debate the alternative solutions within the class.
12.2.2	Using a given set of materials (e.g., film canisters, seltzer tablets, water, measuring devices such as thermometers and stopwatches), students use a logical scientific method to design and conduct an experiment.
12.2.3	Students use a computer interface/CBL* to measure the velocity of objects.
12.2.4	Students compile collected data from an experiment, such as the effectiveness of common household cleaners on bacterial growth, to construct a graph.
12.2.5	Students analyze data collected during a student-designed experiment and draw logical conclusions.
12.2.6	Perform a biological and chemical analysis of a nearby pond, stream or lake. Obtain data from past results via library, Internet, and/or interviews. Compare current and past data for inconsistencies and patterns and discuss the implications of these patterns and inconsistencies.
12.2.7	Burn a pre-massed amount of bread to heat a specific amount of water and monitor the temperature change using a computer or graphing calculator interface. Determine the energy (heat) content of bread using the data collected and the appropriate algebraic equations for calculating heat.
12.2.8	Students present the results of a self-designed experiment to a group of their peers, using an appropriate presentation format.

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Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

Benchmarks

12.3.1	Understand the structure and behavior of atoms
12.3.2	Understand the structure, composition, and properties of matter
12.3.3	Understand the characteristics of chemical reactions
12.3.4	Understand the principles and relations influencing forces and motion
12.3.5	Understand the properties and behaviors of waves
12.3.6	Understand the Law of Conservation of Energy and its implications
12.3.7	Understand interactions of energy and matter.

Examples of Specific Knowledge that Support the Standard and Benchmarks

12.3.1	Subatomic particles and their forces, isotopes, formation of ions, atomic number, atomic weight, electron configuration, periodic table and its organization
12.3.2	Chemical and physical properties; states of matter; classification of matter; types of molecules; types of bonds; intermolecular forces; writing formulas, naming compounds, acids, bases, salts; organic and inorganic compounds
12.3.3	Model chemical reactions (write and balance equations, predict products, identify types of reactions), role of catalysts, energy changes, reaction rates
12.3.4	Newton's laws of motion, vectors, velocity, acceleration, friction, simple machines, forces (e.g., gravitational, electric and magnetic)
12.3.5	Properties of waves (e.g., wavelengths, frequency, reflection, refraction), electricity, circuits, Ohm's Law, properties of sound, properties of light, types of waves, magnetism
12.3.6	Forms of energy (e.g., nuclear, light, heat, geothermal, electrical, etc), energy transformations (e.g., potential to kinetic, electrical to heat, etc.), thermodynamics
12.3.7	Energy flow (e.g., chemical reactions, exothermic, endothermic, bond making & bond breaking, phase changes), effects on matter (e.g., randomness/entropy, convection, radiation, insulation), measuring energy (e.g., specific heat, heat vs. temperature, calorimeter, thermometer, heat units)

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Examples of Activities that Support the Standard and Benchmarks

12.3.1	Students use a bag containing three types of beans representing three isotopes of a single element to calculate percent composition of each isotope and determine average mass. Using this information, they calculate atomic weight. (A similar activity, "Bean Salad," can be found in *CRISTAL* materials.)
12.3.2	Students use qualitative analysis (e.g., flame tests, precipitates, chromatography) to identify unknown chemicals.
12.3.3	Conduct a variety of simple chemical reactions, identify the reactants in each reaction and the reaction indicators (heat, precipitate, gas evolution, etc.), and predict possible products. (If you wish, continue by writing correct chemical formulas for reactants and products and a balanced equation for each reaction.)
12.3.4	Students analyze the motion of moving objects using a CBL* and motion detector. (CBLs are available from Vernier Software www.vernier.com.)
12.3.5	Students design series and parallel circuits using Christmas tree lights (strands can be cut into individual lights) and a DC power source. They measure total resistance using a multi-meter and calculate current in the circuit. They vary the circuit by adding or removing bulbs, and then predict and measure the resistance.
12.3.6	Students use a calorimeter to determine the specific heat of ice. Given size parameters, students design containers to keep ice cubes frozen the longest period of time.
12.3.7	Students take a real-life or virtual field trip* to a nuclear power plant. They research the production and use of nuclear power and debate the pros and cons of it.

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Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

Benchmarks	
12.4.1	Understand the structure and function of cells and their components
12.4.2	Understand how systems and organisms develop through the differentiation of cells
12.4.3	Understand the molecular basis of heredity
12.4.4	Understand the theory of biological evolution
12.4.5	Understand the interdependence of organisms and their environments*
12.4.6	Understand the role of matter and energy in the organization of living systems

Examples of Specific Knowledge that Support the Standard and Benchmarks	
12.4.1	Types of cells (e.g., plant, animal, bacterial); cell organelles, cellular function (e.g., diffusion, osmosis, protein synthesis)
12.4.2	Levels of organization; functions of cells; specialization of cells, organelles, tissues, organs; comparisons among diverse organisms
12.4.3	Structure and function of DNA, RNA, mutations, DNA analysis, mitosis, meiosis, Mendelian genetics, genetic engineering, cloning
12.4.4	Classification, taxonomy, adaptation, mutation, natural selection, speciation, species change through time, extinction, differential reproduction
12.4.5	Food webs, food chains, trophic pyramid, symbiosis, mutualism, predator-prey and parasite-host relations, habitat, soil nutrients, water, weather, climate
12.4.6	Natural cycles (e.g., water, CO_2-O_2, nitrogen), photosynthesis/respiration

Examples of Activities that Support the Standard and Benchmarks	
12.4.1	Students prepare slides of various cells (e.g., onion, skin, fresh muscle), using staining procedures and noting similarities and differences. They identify as many structures as possible and explain how cell functions are regulated to allow organisms to respond to the environment and to control and coordinate growth and differentiation
12.4.2	Students identify pond organisms (simple and complex), using a field guide, and relate form and function to the organism's environment.
12.4.3	Students use electrophoresis to observe the rate of migration of various DNA fragments. They discuss how the patterns can be used in forensics.
12.4.4	Grow Wisconsin Fast Plants, *Brassica*, and examine for number of hairs on stem. Pollinate plants with few hairs with pollen from plants with few hairs, and pollinate other plants with many hairs with pollen from plants with many hairs. Count hairs for each generation evidencing the number of hair declines in the first case and increases in the second.
12.4.5	Students design and play an ecosystem game show (e.g., Jeopardy, Wheel of Fortune). Students research relations among organisms within the ecosystem.
12.4.6	Students measure the oxygen and carbon dioxide production of *Elodea* using temperature and light as variables.

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Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

Benchmarks	
12.5.1	Understand the origin and evolution* of the earth system
12.5.2	Understand the origin and evolution* of the universe
12.5.3	Understand the principles governing energy and its transfer in the earth system
12.5.4	Understand the interactions among the geosphere, hydrosphere, atmosphere, and biosphere
12.5.5	Understand the effects that geologic processes and human activities can have on the environment

Examples of Specific Knowledge that Support the Standard and Benchmarks	
12.5.1	Nebular hypothesis for the formation of planets; age of the Earth; radiometric age determination; fossil record and evolution of life forms; evolution of Earth's atmosphere; Plate Tectonics
12.5.2	Big Bang theory; Doppler effect; determination of the age of the universe; light years; types, formation and evolution of stars; solar energy and nuclear reactions
12.5.3	Equilibrium, dynamic equilibrium, positive and negative feedbacks, radiation, latent heat, convection, heat of fusion, heat of vaporization, Law of Conservation of Energy
12.5.4	Law of Conservation of Matter, biogeochemical cycles, the carbon cycle, nitrogen cycle; water cycle, plate tectonics, the rock cycle, transfer of energy and matter among the spheres
12.5.5	Prediction of natural hazards (e.g., earthquakes, volcanoes, floods, hurricanes); human activities (e.g., dams, levees, farming practices, deforestation, land-use practices, land-management strategies)

Examples of Activities that Support the Standard and Benchmarks.	
12.5.1	Students develop and complete a project (e.g., research paper, multi-media presentation, poster, skit) to explain the origin and evolution of the earth system or the universe
12.5.2	Students conduct a study of the geology of an area near the school and describe the likely history of the region, using observations and reference materials.
12.5.3	Students make a brochure for newcomers to the region, providing an overview of the local climate and an explanation of the factors contributing to that climate.
12.5.4	Students collect and identify rocks and minerals of North Dakota. They choose one of the collected samples and write a story about its history.
12.5.5	Students identify or visit (virtually or actually) a place (e.g., oil field, coal mine, power plant, gravel pit, fossil area) in which humans have made some kind of impact on the environment. They evaluate the positive and negative effects of the human activity.

** - indicates the word or phrase is included in the Glossary*

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

Benchmarks	
12.6.1	Understand the role of technology* in applying scientific knowledge to meet human needs and wants
12.6.2	Use technological design to solve a problem or to improve current technology*
12.6.3	Understand how scientific and technological developments interact and produce consequences

Examples of Specific Knowledge that Support the Standard and Benchmarks	
12.6.1	Scientific principles used in common technology* (e.g., household appliances, automotive parts, agricultural equipment, textiles, fabrics, computers, Internet resources, CD-ROMs)
12.6.2	Design principles*, use of computer-assisted* tools and Internet and/or other appropriate technology*, research skills, the role of creativity and imagination
12.6.3	Ways in which technology* has helped to advance science, pros and cons of technology*, limitations and recent advancements in technology*

Examples of Activities that Support the Standard and Benchmarks	
12.6.1	Students research a recent advance in genetic engineering and debate the pros and cons.
12.6.2	Students design a device to meet a specific need (e.g., Invention Day, Duracell competition, Science Olympiad).
12.6.2	Students research a specific technology* from their home, find out how and why it was invented, and analyze what it would be like without the technology.
12.6.3	Students solve a problem with and without using current technology* and compare the two approaches. Determine the specific heat or heat capacity of several materials using a standard liquid thermometer, a digital electronic thermometer, and computer probe to record temperature change. Complete calculations first by hand and then with a calculator. Compare the processes used and data collected.

** - indicates the word or phrase is included in the Glossary*

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

Benchmarks	
12.7.1	Understand relations between science and personal and community health issues
12.7.2	Understand the principles governing change and how change affects the environment and quality of life
12.7.3	Understand how natural resources are affected by social and environmental issues and variables
12.7.4	Understand components of and issues affecting environmental quality
12.7.5	Understand the role of science and technology* in addressing local, national, and global challenges
12.7.6	Understand how science and technology* influence personal, industrial, and cultural decision making

Examples of Specific Knowledge that Support the Standard and Benchmarks	
12.7.1	Physiology of the disease process, fitness, substance abuse, nutrition
12.7.2	Factors affecting population change (e.g., pyramids, food webs, symbiosis, carrying capacity, overpopulation, disease, food supply, algal blooms, resources, conservation practices)
12.7.3	Renewable verses nonrenewable resources, management of natural resources, alternate resources, limitations of natural resources
12.7.4	Quality standards for water, atmosphere, and soil; environmental laws, political issues, and activities that impact the quality of the environment
12.7.5	Effects of human activity (e.g., waste management, genetic pollution), effects of natural phenomenon (e.g., volcanoes, floods, global weather) on the environment and human and other populations, monitoring and evaluating systems
12.7.6	Bioethics* (e.g., organ transplants, cloning, genetic manipulation, use of genetic profile, archeological finds), land and water management, resource management

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Examples of Activities that Support the Standard and Benchmarks

12.7.1	Students participate in a simulation of disease transmission by contact when a fluorescent material is applied to the classroom door handle. They observe the patterns of transmission using a UV light. (Contact your local sheriff's department for the chemical.
12.7.2	Students are provided with a population of organisms (e.g., bacteria, algae, protozoa). Using the sample, they analyze the changes in population over time and the resulting effects on the microenvironment (e.g., dissolved oxygen, pH).
12.7.3	Students select a topic of concern (e.g., power plant emissions, waste management, seatbelt use, cloning), research it, and defend their viewpoints.
12.7.4	In cooperative* groups, students select a local water source and periodically conduct water quality tests. The class compiles the data, notes variations, and holds a class discussion on the water quality of their sources.
12.7.5	Students research current topics that have global impact (e.g., Mad Cow disease, birth control, rain forests), state their viewpoints, and support their reasoning.
12.7.6	Students clone a plant such as a carrot or a Wisconsin Fast Plant. (Information on the procedure can be obtained from Carolina Biological.) Students research the application of cloning to humans.

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Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

Benchmarks

12.8.1	Understand how cultural elements and intellectual perspectives have influenced the development of science throughout history
12.8.2	Understand the nature of scientific knowledge
12.8.3	Understand how human characteristics influence scientific advancement
12.8.4	Understand the role of science and scientists in theoretical and applied situations

Examples of Specific Knowledge that Support the Standard and Benchmarks

12.8.1	Views and attitudes that have influenced the development of science (e.g., religious, superstitions, cultural tradition, folklore, legends, previous knowledge), examples of theories that have changed over time (e.g., alchemy, atomic structure, model of the solar system)
12.8.2	Characteristics of scientific knowledge (e.g., consistent and repeatable data, best explanation for natural phenomena, shared methods and results, open to question and reexamination, probability greater than chance, logical, often allows predictions)
12.8.3	Scientific attitudes* and beliefs; skepticism; rules of ethical conduct; cooperation; sharing of methods and results with the public; science done by individuals and groups, by amateur and professional scientists
12.8.4	Difference between theoretical and applied science, careers in science or that use science, characteristics of science careers (e.g., prerequisites, job expectations, employment possibilities), identification of scientists as role models

Examples of Activities that Support the Standard and Benchmarks

12.8.1	Students research a product or invention that has originated from, or been influenced by, a diverse culture*.
12.8.1	Students research atomic theory and build models of atoms that represent the changes over time.
12.8.2	Students design and carry out a scientific experiment.
12.8.3	Students analyze their thoughts and behaviors expressed while carrying out an experiment.
12.8.4	Students select and research a career (salary information, educational requirements, career possibilities, etc.).
12.8.4	Students participate in job shadowing and internship experiences in person or communicate with an individual in their chosen fields through e-mail.

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Summary of Benchmarks by Standard

Standard 1: UNIFYING CONCEPTS

Students understand unifying concepts and processes of science.

Grades K- 4

4.1.1	Understand that a system is made up of parts that work together
4.1.2	Understand that models help explain objects and ideas
4.1.3	Understand that changes might occur in properties of materials and in position and motion of objects
4.1.4	Understand that change might occur in order to maintain balance in a system
4.1.5	Understand relations between form and function

Grades 5 – 8

8.1.1	Understand the structure and organization of systems
8.1.2	Understand how models can be used to explain scientific principles
8.1.3	Understand how patterns of change and constancy apply to various systems
8.1.4	Understand how change affects systems in equilibrium
8.1.5	Understand relations between form and function

Grades 9 – 12

12.1.1	Understand the structure, organization, and dynamics of systems
12.1.2	Understand how scientists create and use models
12.1.3	Understand concepts of constancy and change
12.1.4	Understand principles governing evolution* and equilibrium within systems
12.1.5	Understand relations between form and function

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Standard 2: SCIENCE INQUIRY

Students use the process of science inquiry.

Grades K – 4

4.2.1	Use and integrate the science processes of observing, questioning, hypothesizing, and reflecting to investigate their world
4.2.2	Use simple scientific tools to gather information
4.2.3	Plan and conduct controlled investigations
4.2.4	Keep records of their investigations and share their results with others as scientists do
4.2.5	Review scientific investigations done by others as scientists do

Grades 5 – 8

8.2.1	Understand how questions that can be answered by scientific inquiry* differ from those that can not
8.2.2	Design and carry out a scientific investigation
8.2.3	Use appropriate technology* and techniques to gather and interpret data
8.2.4	Use acquired data to develop descriptions, explanations, predictions, and models
8.2.5	Use acquired data and critical analysis to formulate conclusions
8.2.6	Understand that alternative explanations and procedures in scientific inquiry* may exist
8.2.7	Communicate the aspects of a scientific investigation in a variety of ways
8.2.8	Use mathematics in the process of scientific inquiry*

Grades 9 – 12

12.2.1	Identify problems, develop appropriate questions, and recognize relevant concepts that guide scientific investigations
12.2.2	Design and conduct investigations in various ways to solve problems in a variety of forms
12.2.3	Use appropriate measuring systems and tools
12.2.4	Collect, organize, analyze, and use data to solve problems
12.2.5	Formulate conclusions based upon experimental data
12.2.6	Identify and analyze alternative explanations to scientific problems
12.2.7	Use knowledge and skills from other academic disciplines to solve problems in science
12.2.8	Use various forms of communication to present results and explanations of scientific investigations

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Standard 3: PHYSICAL SCIENCE

Students understand the basic concepts and principles of physical science.

Grades K – 4

4.3.1	Know properties of objects and materials
4.3.2	Know that position and motion of objects can be described and changed
4.3.3	Know characteristics of light, heat, electricity, and magnetism

Grades 5 – 8

8.3.1	Understand properties of matter and their relations to physical and chemical changes in matter
8.3.2	Understand relations between force and motion
8.3.3	Know the characteristics of various forms of energy and the principles governing energy transformation and transfer

Grades 9 – 12

12.3.1	Understand the structure and behavior of atoms
12.3.2	Understand the structure, composition, and properties of matter.
12.3.3	Understand the characteristics of chemical reactions
12.3.4	Understand the principles and relations influencing forces and motion.
12.3.5	Understand the properties and behaviors of waves
12.3.6	Understand the Law of Conservation of Energy and its implications.
12.3.7	Understand interactions of energy and matter

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Standard 4: LIFE SCIENCE

Students understand the basic concepts and principles of life science.

Grades K –4

4.4.1	Understand characteristics of organisms
4.4.2	Know the characteristics of the life cycle of organisms
4.4.3	Understand relations between organisms and environments*
4.4.4	Know that changes in life forms have occurred over time

Grades 5 – 8

8.4.1	Understand relations between structure and function in living systems
8.4.2	Understand the basic principles governing genetics and reproduction
8.4.3	Understand regulation in and behavior of organisms
8.4.4	Understand the interactions of populations in ecosystems
8.4.5	Understand the cause and significance of diversity and adaptations of organisms

Grades 9 – 12

12.4.1	Understand the structure and function of cells and their components
12.4.2	Understand how systems and organisms develop through the differentiation of cells
12.4.3	Understand the molecular basis of heredity
12.4.4	Understand the theory of biological evolution
12.4.5	Understand the interdependence of organisms and their environments*
12.4.6	Understand the role of matter and energy in the organization of living systems

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Standard 5: EARTH AND SPACE SCIENCE

Students understand the basic concepts and principles of earth and space science.

Grades K – 4	
4.5.1	Know the properties and uses of earth materials
4.5.2	Know the names and basic characteristics of celestial objects
4.5.3	Know ways that changes occur in Earth's surface and atmosphere

Grades 5 – 8	
8.5.1	Understand the structure and processes of Earth
8.5.2	Understand landforms and the processes that change the surface of Earth
8.5.3	Understand the types of evidence used to reconstruct the history of Earth and the evolution of life
8.5.4	Understand the structure and processes of Earth's atmosphere
8.5.5	Understand the structure and processes of the oceans
8.5.6	Understand the Theory of Plate Tectonics
8.5.7	Understand the structure and features of our solar system and the universe and the relations between them

Grades 9 – 12 Benchmarks	
12.5.1	Understand the origin and evolution of the earth system
12.5.2	Understand the origin and evolution of the universe
12.5.3	Understand the principles governing energy and its transfer in the earth system
12.5.4	Understand the interactions among the geosphere, hydrosphere, atmosphere, and biosphere
12.5.5	Understand the effects that geologic processes and human activities can have on the environment

** - indicates the word or phrase is included in the Glossary*

Standard 6: SCIENCE AND TECHNOLOGY*

Students understand relations between science and technology.*

Grades K – 4 Benchmarks

4.6.1	Know the various forms that technology* can take
4.6.2	Understand how natural objects differ from those made by humans
4.6.3	Design technological solutions to a problem
4.6.4	Understand concepts and applications of science and technology

Grades 5 – 8 Benchmarks

8.6.1	Design a solution, using science and technology, to a problem related to human needs or wants
8.6.2	Understand how science and technology* are similar and different
8.6.3	Understand the limitations and possibility for unintended outcomes of technological solutions

Grades 9 – 12 Benchmarks

12.6.1	Understand the role of technology* in applying scientific knowledge to meet human needs and wants
12.6.2	Use technological design to solve a problem or to improve current technology*
12.6.3	Understand how scientific and technological developments interact and produce consequences

** - indicates the word or phrase is included in the Glossary*

Standard 7: SCIENCE AND OTHER AREAS

Students understand relations between science and personal, social, and environmental issues.

Grades K – 4 Benchmarks	
4.7.1	Know basic concepts of personal health
4.7.2	Understand characteristics of and changes in populations of organisms
4.7.3	Understand how different types of resources affect our lives
4.7.4	Understand how changes in environments* affect populations of organisms
4.7.5	Understand how culture* influences the way people relate to science

Grades 5 – 8 Benchmarks	
8.7.1	Understand how science influences personal health
8.7.2	Understand how limiting factors* affect populations, resources, and environments*.
8.7.3	Understand the challenges presented to the individual and society by human-induced hazards
8.7.4	Use a systematic approach to analyze risks and benefits
8.7.5	Understand the limitations of science and technology in dealing with social issues

Grades 9 – 12 Benchmarks	
12.7.1	Understand relations between science and personal and community health issues
12.7.2	Understand the principles governing change and how change affects the environment and quality of life
12.7.3	Understand how natural resources are affected by social and environmental issues and variables
12.7.4	Understand components of and issues affecting environmental quality
12.7.5	Understand the role of science and technology* in addressing local, national, and global challenges
12.7.6	Understand how science and technology* influence personal, industrial, and cultural decision making

** - indicates the word or phrase is included in the Glossary*

Standard 8: HISTORY AND NATURE OF SCIENCE*

Students understand the history and nature of science.*

Grades K-4 Benchmarks

4.8.1 Understand how people have used science throughout time
4.8.2 Know basic beliefs and attitudes that scientists share
4.8.3 Understand the role of individuals and cultures in contributing to science

Grades 5 – 8 Benchmarks

8.8.1 Understand how science is influenced by human qualities
8.8.2 Understand how scientists' beliefs and attitudes* influence their work
8.8.3 Understand how science has changed from a historical perspective

Grades 9 – 12 Benchmarks

12.8.1 Understand how cultural elements and intellectual perspectives have influenced the development of science throughout history
12.8.2 Understand the nature of scientific knowledge
12.8.3 Understand how human characteristics influence scientific advancement
12.8.4 Understand the role of science and scientists in theoretical and applied situations

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Resources

Agencies

Coalition for Conservation and Environmental Education
C/O Glenda Fauske
North Dakota Forest Service
Molberg Forestry Center
1st and Brander Street,
Bottineau, ND 58318

County Soil Conservation Districts
(source of conservation materials, sponsor of field trips, etc.)
See listings in local phone book

Local Natural Resources Conservation Service
see listing in phone book under "U.S. Government, Department of Agriculture"

North Dakota Crime Lab
Box 1023
Bismarck, ND 58501

North Dakota Game and Fish Department
100 N. Bismarck Expressway
Bismarck, ND 58501-5095
Phone: 701-221-6300
www.state.nd.us/gnf/

North Dakota Geological Survey
(publications, topographic maps, answers to questions about earth science and mineral resources)
600 E. Boulevard Avenue
Bismarck, ND 58505-0840
Phone: 701-328-8000
FAX: 701-328-88010
www.state.nd.us/ndgs/

North Dakota Natural Resources Conservation Service
P.O. Box 1458
200 E. Rosser Avenue
Bismarck, ND 58501

North Dakota State Water Commission
900 East Boulevard Avenue, Dept. 770
Bismarck, ND 58505-0850
Phone: 701-328-4833

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North Dakota Teacher Center Network

- **Bismarck-Mandan Teacher Center**
  1107 Airport Rd.
  Bismarck, ND 58504-6712
  Phone: 701-221-3420
  Fax: 701-221-3711

- **Devils Lake Area Teacher Center**
  325 7th Street
  Devils Lake, ND 58301-2488
  Phone: 701-662-7644
  Fax: 701-662-7649

- **West River Teacher Center**
  Dickinson State University
  1679 6th Avenue W.
  Dickinson, ND 58601-2904
  Phone: 701-227-2139
  Fax: 701-227-2028

- **Fargo, West Fargo, Moorhead Area Teacher Center**
  415 4th Street, N
  Fargo, ND 58102-4514
  Phone: 701-241-4936
  Fax: 701-241-4929

- **Grand Forks Area Teacher Center**
  Box 7189,UND Station
  Grand Forks, ND 58202-7189
  Phone: 701-777-4394
  Fax: 701-777-4393

- **Mayville Area Teacher Center**
  330 3rd St. NE
  Mayville, ND 58257-1299
  Phone: 701-786-4796
  Fax: 701-786-4890

- **Minot Area Teacher Center**
  1609 4th Avenue NW
  Minot, ND 58703-2911
  Phone: 701-857-4488 or 857-4467
  Fax: 701-857-4489

- **Valley City Area Teacher Center**
  101 College St. SW
  Valley City, ND 58072-4098
  Phone: 701-845-7221 or 845-8514
  Fax: 701-845-7437

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- **Wahpeton Area Teacher Center**
  NDSCS
  800 6th St. N
  Wahpeton, ND 58076-0002
  Phone: 701-671-2242
  Fax: 701-671-2145

- **Williston Area Teacher Center**
  UND-W
  P.O. Box 1326
  Williston, ND 58802-1326
  Phone: 701-774-4229
  Fax: 701-774-4275

United States Department of Agriculture Natural Resources Conservation Service
Phone: 202-720-3210
http://www.nrcs.usda.gov

Curriculum Materials

Applications in Biology/Chemistry (ABC)
(a contextual approach to laboratory science)
Kits available from
Sargent-Welch
Phone: 1-800-727-4368
www.sargentwelch.com

Carolina Biological Supply Company (Applications in Biology/Chemistry (ABC) Curriculum)
2700 York Road
Burlington, NC 27215
Phone: 1-800-334-5551
www.carolina.com

CCI Publishing (Applied Biology Chemistry text)
P.O. Box 21206
Waco, TX 76702-1206
1-800-231-3015
http://www.cord.org/

CRISTAL (Chemistry Resources and Instructional Strategies for All Learners)
Dr. Jody Stone
Price Laboratory School
University of Northern Iowa
Cedar Falls, IA 50614-3593
Phone: 319-273-6466

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Gateway to Science Trunks
Gateway Mall
2700 State Street
Bismarck, ND
Phone: 701-258-1975

Great Explorations in Math and Science (GEMS)
(inquiry-based science and math curriculum guides)
Lawrence Hall of Science
University of California – Berkeley
Berkeley, CA 94720
Phone: 510-642-8718
www.lhs.berkeley.edu/gems

National Women's History Project
(source for books and materials on women in science)
7738 Bell Road
Windsor, CA 95492-8518
Phone: 707-838-6000
www.nwhp.org

North Dakota Geological Survey
600 E. Boulevard Ave.
Bismarck, ND 58505-0840 U.S.A.
Phone: 701-328-8000
http://www.state.nd.us/ndgs

North Dakota Project WET (Water Education for Teachers) Activity Guide
Bill Sharff, Project WET Director
ND Water Commission
900 E. Boulevard Avenue
Bismarck, ND 58505
Phone: 701-328-4833
www.bsharff@water.swc.state.nd.us
Other curriculum guides: **W.O.W., Discover a Watershed, Conserve Water, Correlation Document-Project WET K-12 Guide and North Dakota Content Standards, North Dakota Wetlands Discover Guide** (plus many other educational materials)

PASCO Scientific
(source of CBLs, probes, and other science laboratory apparatus)
10101 Foothills Blvd.
Box 619011
Roseville, CA 95747
Phone: 1-800-772-8700

Pederson's Field Guides
Available from book stores and science supply companies

PRISMS (Physics Resources and Instructional Strategies for Motivating Students)
(conceptual physics education curriculum)
Physics Department
University of Northern Iowa
Cedar Falls, IA 50614
Phone: 319-273-2324
www.prisms.uni.edu

Project Learning Tree Guides
(environmental education)
Glenda Fauske
North Dakota Forest Service
307 First Street E.
Bottineau, ND 58318-1100
Phone: 701-228-5422

Project WET Curriculum and Activity Guide
201 Culbertson Hall
Montana State University
Bozeman, MT 59717-0570
rwwet@msu.oscs.montana.edu

Project WILD Activity Guide
(interdisciplinary, supplemental environmental education program)
Dave Jensen, Director
North Dakota Game and Fish Department
100 N. Bismarck Expressway
Bismarck, ND 58501-5095
Phone: 701-328-6322

SCI Technologies (computer-based laboratory interface that allows students to collect and analyze data. Includes hardware, software, experiments, and curriculum support materials)
1716 West Main Street, Suite 4
Bozeman, MT 59715
Phone: 1-800-662-2091
Fax: 406-585-8840
www.scitechnologies.com/

Science Education for Public Understanding Program (SEPUP)
(issue-oriented science instructional materials)
Lawrence Hall of Science
University of California – Berkeley
Berkeley, CA 94720
Phone: 510-642-8718
www.lhs.berkeley.edu
Kits available through Sargent-Welch
Phone: 1-800-727-4368
www.sargentwelch.com

Tasa Graphic Arts
(source of interactive CD-ROM programs in Earth science)
9301 Indian School Rd. NE, Ste. 208
Albuquerque, NM 87112-2861
Phone: 1-800-293-2725
www.swcp.com/~tasa

TIMS (Teaching Integrated Math and Science)
Howard Goldberg, Department of Physics
Philip Wagreich, Department of Mathematics
University of Illinois, Chicago
M/c 250
UIC, Box 4348
Chicago, IL 60680
Phone: 312-996-2448

VWR Scientific Products/Science Education (Applications in Biology/Chemistry (ABC) Curriculum)
P.0. Box 5229
Buffalo Grove, IL 60089
TEL: 800-727-4368

Vernier Software
(source of computer-based laboratories and probes)
8565 SW Beaverton-Hillsdale Hwy.
Portland, OR 97225-2429
Phone: 503-297-1760 www.vernier.com

Opportunities for Students

Duracell/NSTA Invention Challenge
1840 Wilson Blvd.
Arlington, VA 22201-3000

Professional Organizations

American Geological Institute (AGI)
4220 King Street
Alexandria, VA 22302-1502
Telephone: 703-379-2480
FAX: 703-379-7563
http://www.agiweb.org/

Geological Society of America (GSA)
P.O. Box 9140
Boulder, CO 80301-9140
Phone numbers: (303) 447-2020, (800) 472-1988
http://www.geosociety.org/

National Association of Biology Teachers
11250 Roger Bacon Drive, #19
Reston, Virginia 20190-5202
Phone: (703) 471-1134 or (800) 406-0775
Fax: (703) 435-5582
Email: office@nabt.org
Web site: http://www.nabt.org/

National Association of Geoscience Teachers (NAGT)
P.O. Box 5443
Bellingham, Washington 98227-5443
Telephone: 360-650-3587
http://www.nagt.org/

National Science Teachers Association
1840 Wilson Boulevard
Arlington, Virginia 22201-3000
Telephone: (703) 243-7100, Facsimile: (703) 243-7177
http://www.nsta.org/

North Dakota Academy of Science
PO Box 7081
Grand Forks, ND 58202-7081

North Dakota Science Teachers Association
http://www.ndsta.k12.nd.us/

Web Sites

Discover Channel and TLC program guides and other science information
www.discovery.com/

International History, Philosophy and Science Teaching Group
http://www1.umn.edu/ships/hpst/

Links to science and math resources
www.csun.edu/~vceed009/lesson.html
www.educationindex.com/education_resources.html
dir.yahoo.com/Science/

National Association of Biology Teachers
http://www.nabt.org/

National Science Education Standards
http://books.nap.edu/catalog/4962.html

National Science Teachers Association (NSTA)
http://www.nsta.org/

National Weather Service
www.nws.noaa.gov/

North Dakota Science Olympiad
www.ndsu.nodak.edu/olympiad/

Northern Prairie Wildlife Research Center
Jamestown, ND
(Excellent website for species data and distributions)
www.npwrc.usgs.gov

National Aeronautics and Space Administration
www.nasa.gov/

Teachers Helping Teachers
http://www.pacificnet.net/~mandel/index.html

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Glossary

Attitudes – see “scientific attitudes”.

Atomic mass (weight) - the average mass of the naturally occurring isotopes of an element, expressed in atomic mass units (AMU). Atomic weight is still used by many scientists and most texts. Some texts use isotopic mass to refer to the mass of the particular isotopic forms of an element.

Bioethics – the application of ethics in biology.

Biological evolution – change in the genetic makeup of a population of a species in successive generations. If continued long enough, it can lead to the formation of a new species. Note that populations-not individuals-evolve. (Miller, Jr. 2000)

Cooperative learning – learning in cooperation with others. Students are organized into small teams that work together to accomplish academic and non-academic tasks while at the same time developing important social skills.

Culture - the totality of manners, customs, and values of a given society, inclusive of its socioeconomic system, political structure, science, religion, education, art, and entertainment.

CBL – calculator-based laboratory.

Computer-assisted tools – tools involving computers, such as data sensors and recorders (e.g., CBL, GIS [Geographic Information System]), and software programs such as CAD (computer-assisted design) programs and statistical programs.

Design principles – steps include: identify problem; propose/design solution (recognizing possible constraints of cost, materials, time, space, safety, etc.); implement proposed solution (use suitable tools, techniques, and quantitative measurements when appropriate); evaluate product or design; (modify design based on results of evaluations); communicate the problem, design, and solution.

Diverse populations – the variety and complexity of species present and interacting in an ecosystem and relative abundance of each.

E.g., (E.g.,)- for example; for instance. (Barnhart, 1987).

Environments – the sum of all external conditions and influences (living and nonliving) that affect the development and, ultimately, the survival of an organism or group of organisms.

Evolution – series of changes that account for the present form and function of objects, organisms, and systems. (Commonly refers to biological evolution; also describes changes in the universe. See biological evolution.)

Fact – in science, an observation that has been repeatedly confirmed. (National Academy of Sciences, 1998).

Genetic pollution – accidental or intentional introduction of nonnative species, including bioengineered species, into biological communities.

Hypothesis – a testable statement about the natural world that can be used to build more complex inferences and explanations (National Academy of Sciences, 1998).

I.e., – that is; that is to say; namely (Barnhart, 1987).

Inherited characteristics – traits or features of living organisms which are passed from one generation to a following generation, such as the color of flowers or the number of limbs of an animal.

Inquiry–based – an approach to instruction in which students ask researchable questions, formulate testable hypotheses, design and perform appropriate experiments, collect and analyze data to form conclusions, and present results in appropriate ways; investigations that involve asking and answering a question and comparing the answer with what scientists already know about the world

Intermolecular forces (van der Waal Forces) - The short range attractive forces (London dispersion forces, dipole-dipole forces, hydrogen bonds) between molecules comprising a liquid or solid substance that influence phases and phase changes, solubility, boiling points, melting points, etc.

Law –(see scientific law.)

Learned characteristics – traits or features which living things obtain through interaction with the environment; not inherited

Limiting factor – 1) condition or component that influences the size of a population in an ecosystem (e.g., food supply, disease, shelter, water); 2) condition or component which restricts a process (e.g., nutrients or water for plant growth, amount of reactant for a chemical reaction).

Nature of science – questioning and investigating (using the processes of science) with appropriate scientific attitudes, which results in scientific information (the products of science). The nature of science refers to what educators call the three aspects of science: scientific processes, scientific products, scientific attitudes (Carin, 1993; Gega, 1994).

Pseudoscience - false or pretended science (Barnhart, 1987); a system of theories, assumptions, and methods erroneously regarded as scientific (Merriam-Webster, 2000).

Science –1) a process which attempts to understand the order in nature and which uses that knowledge to make predictions about what might happen in nature; 2) knowledge resulting from scientific investigations.

Scientific attitudes – a way of thinking a person has, a frame of mind which incorporates certain intellectual and emotional attitudes. These attitudes are characterized by such attributes as curiosity, inventiveness, openness to new or differing ideas, objectivity, having a willingness to suspend judgment until enough facts are known, having a positive approach to failure, being skeptical (insisting on sufficient evidence before making judgments or conclusions) and being responsible in science decisions. However, all scientists do not necessarily exhibit this ideal. (Brauner, 1994; Gauld, 1982). Also referred to as “scientific habits of mind” (e.g., intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas).

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Scientific inquiry – The diverse ways in which scientists study the natural world and propose explanations based on evidence derived from their work. It also refers to the activities through which students develop knowledge and understanding of scientific ideas as well as understanding of how scientists study the natural world.

Scientific law – description of what scientists find happening in nature over and over in the same way, without known exception. (Miller, Jr., 2000)

Scientific literacy – the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.

Scientific processes – the mental and physical processes, the thinking and doing processes, which encompass the following: classifying data, identifying problems, manipulating science materials, observing, questioning, hypothesizing, gathering information, analyzing data, recording information, communicating thoughts/results, creating models, identifying variables, evaluating information, interpreting data, measuring, replicating experiments, making decisions, and generalizing science information (Brauner, 1994).

Scientific products – the facts, concepts, theories, principles, and laws of science (Brauner, 1994; Carin, 1993).

Technology – 1) application of science to create new products and processes intended to meet human needs or wants; 2) tools and techniques used to conduct inquiry (e.g., microscopes, eye droppers).

Theory – (**scientific theory)** In science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses. [Differentiated from the popular definition of theory of a “guess” or “hunch”] “Cell theory says that all living things are composed of cells. The heliocentric theory says that the earth revolves around the sun rather than vice versa. Such concepts are supported by such abundant observational and experimental evidence that they are no longer questioned in science.” (National Academy of Sciences, 1998)

Virtual field trip – field trip on the Internet

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