Michael Elsohn Ross The World Comes In OEMA 10/13/06 8AM-11:30 AM

Note to participants:
Please at least five fiction and non-fiction art and science books for a age range you are interested in developing materials for. The fiction books can be any books that you think might connect with an art or science topic. For example Charlotte's Web or Never Cry Woof might work for science and Fredrick (Leo Lioni) and The Paper Princess (Elisa Kleven) could work for art.

National Science Standards

Content Standards: K-4

Science as Inquiry

CONTENT STANDARD A:
As a result of activities in grades K-4, all students should develop

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

DEVELOPING STUDENT ABILITIES AND UNDERSTANDING

From the earliest grades, students should experience science in a form that engages them in the active construction of ideas and explanations that enhance their opportunities to develop the abilities of doing science. Teaching science as inquiry provides teachers with the opportunity to develop student abilities and to enrich student understanding of science. Students should do science in ways that are within their developmental capabilities. This standard sets forth some abilities of scientific inquiry appropriate for students in grades K-4.

In the early years of school, students can investigate earth materials, organisms, and properties of common objects. Although children develop concepts and vocabulary from such experiences, they also should develop inquiry skills. As students focus on the processes of doing investigations, they develop the ability to ask scientific questions, investigate aspects of the world around them, and use their observations to construct reasonable explanations for the questions posed. Guided by teachers, students continually develop their science knowledge. Students should also learn

through the inquiry process how to communicate about their own and their peers' investigations and explanations.

There is logic behind the abilities outlined in the inquiry standard, but a step-by-step sequence or scientific method is not implied. In practice, student questions might arise from previous investigations, planned classroom activities, or questions students ask each other. For instance, if children ask each other how animals are similar and different, an investigation might arise into characteristics of organisms they can observe.

Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. In elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry. They can design investigations to try things to see what happens--they tend to focus on concrete results of tests and will entertain the idea of a "fair" test (a test in which only one variable at a time is changed). However, children in K-4 have difficulty with experimentation as a process of testing ideas and the logic of using evidence to formulate explanations.

GUIDE TO THE CONTENT STANDARD

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

ASK A QUESTION ABOUT OBJECTS, ORGANISMS, AND EVENTS IN THE ENVIRONMENT. This aspect of the standard emphasizes students asking questions that they can answer with scientific knowledge, combined with their own observations. Students should answer their questions by seeking information from reliable sources of scientific information and from their own observations and investigations.

PLAN AND CONDUCT A SIMPLE INVESTIGATION. In the earliest years, investigations are largely based on systematic observations. As students develop, they may design and conduct simple experiments to answer questions. The idea of a fair test is possible for many students to consider by fourth grade.

EMPLOY SIMPLE EQUIPMENT AND TOOLS TO GATHER DATA AND EXTEND THE SENSES. In early years, students develop simple skills, such as how to observe, measure, cut, connect, switch, turn on and off, pour, hold, tie, and hook. Beginning with simple instruments, students can use rulers to measure the length, height, and depth of objects and materials; thermometers to measure temperature; watches to measure time; beam balances and spring scales to measure weight and force; magnifiers to observe objects and organisms; and microscopes to observe the finer details of plants, animals, rocks, and other materials. Children also develop skills in the use of computers and calculators for conducting investigations.

USE DATA TO CONSTRUCT A REASONABLE EXPLANATION. This aspect of the standard emphasizes the students' thinking as they use data to formulate explanations. Even at the earliest grade levels, students should learn what constitutes evidence and judge the merits or strength of the data and information that will be used to make explanations. After students propose an explanation, they will appeal to the knowledge and evidence they obtained to support their explanations. Students should check their explanations against scientific knowledge, experiences, and observations of others.

COMMUNICATE INVESTIGATIONS AND EXPLANATIONS. Students should begin developing the abilities to communicate, critique, and analyze their work and the work of other.

UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting).
- Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations.
- Scientists make the results of their investigations public; they describe the investigations in ways that enable others to repeat the investigations.
- Scientists review and ask questions about the results of other scientists' work.

Physical Science

CONTENT STANDARD B:
As a result of the activities in grades K-4, all students should develop an understanding of

- Properties of objects and materials
- Position and motion of objects
- Light, heat, electricity, and magnetism

DEVELOPING STUDENT UNDERSTANDING

During their early years, children's natural curiosity leads them to explore the world by observing and manipulating common objects and materials in their environment. Children compare, describe, and sort as they begin to form explanations of the world. Developing a subject-matter knowledge base to explain and predict the world

requires many experiences over a long period. Young children bring experiences, understanding, and ideas to school; teachers provide opportunities to continue children's explorations in focused settings with other children using simple tools, such as magnifiers and measuring devices.

Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others.

Physical science in grades K-4 includes topics that give students a chance to increase their understanding of the characteristics of objects and materials that they encounter daily. Through the observation, manipulation, and classification of common objects, children reflect on the similarities and differences of the objects. As a result, their initial sketches and single-word descriptions lead to increasingly more detailed drawings and richer verbal descriptions. Describing, grouping, and sorting solid objects and materials is possible early in this grade range. By grade 4, distinctions between the properties of objects and materials can be understood in specific contexts, such as a set of rocks or living materials.

Young children begin their study of matter by examining and qualitatively describing objects and their behavior. The important but abstract ideas of science, such as atomic structure of matter and the conservation of energy, all begin with observing and keeping track of the way the world behaves. When carefully observed, described, and measured, the properties of objects, changes in properties over time, and the changes that occur when materials interact provide the necessary precursors to the later introduction of more abstract ideas in the upper grade levels.

Students are familiar with the change of state between water and ice, but the idea of liquids having a set of properties is more nebulous and requires more instructional effort than working with solids. Most students will have difficulty with the generalization that many substances can exist as either a liquid or a solid. K-4 students do not understand that water exists as a gas when it boils or evaporates; they are more likely to think that water disappears or goes into the sky. Despite that limitation, students can conduct simple investigations with heating and evaporation that develop inquiry skills and familiarize them with the phenomena.

When students describe and manipulate objects by pushing, pulling, throwing, dropping, and rolling, they also begin to focus on the position and movement of objects: describing location as up, down, in front, or behind, and discovering the various kinds of motion and forces required to control it. By experimenting with light, heat, electricity, magnetism, and sound, students begin to understand that phenomena can be observed, measured, and controlled in various ways. The children

cannot understand a complex concept such as energy. Nonetheless, they have intuitive notions of energy--for example, energy is needed to get things done; humans get energy from food. Teachers can build on the intuitive notions of students without requiring them to memorize technical definitions.

Sounds are not intuitively associated with the characteristics of their source by younger K-4 students, but that association can be developed by investigating a variety of concrete phenomena toward the end of the K-4 level. In most children's minds, electricity begins at a source and goes to a target. This mental model can be seen in students' first attempts to light a bulb using a battery and wire by attaching one wire to a bulb. Repeated activities will help students develop an idea of a circuit late in this grade range and begin to grasp the effect of more than one battery. Children cannot distinguish between heat and temperature at this age; therefore, investigating heat necessarily must focus on changes in temperature.

As children develop facility with language, their descriptions become richer and include more detail. Initially no tools need to be used, but children eventually learn that they can add to their descriptions by measuring objects--first with measuring devices they create and then by using conventional measuring instruments, such as rulers, balances, and thermometers. By recording data and making graphs and charts, older children can search for patterns and order in their work and that of their peers. For example, they can determine the speed of an object as fast, faster, or fastest in the earliest grades. As students get older, they can represent motion on simple grids and graphs and describe speed as the distance traveled in a given unit of time.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PROPERTIES OF OBJECTS AND MATERIALS

- Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.
- Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials.
- Materials can exist in different states--solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.

POSITION AND MOTION OF OBJECTS

- The position of an object can be described by locating it relative to another object or the background.
- An object's motion can be described by tracing and measuring its position over time.
- The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.
- Sound is produced by vibrating objects. The pitch of the sound can be varied by changing the rate of vibration.

LIGHT, HEAT, ELECTRICITY, AND MAGNETISM

- Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object.
- Heat can be produced in many ways, such as burning, rubbing, or mixing one substance with another. Heat can move from one object to another by conduction.
- Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass.
- Magnets attract and repel each other and certain kinds of other materials.

Life Science

CONTENT STANDARD C:
As a result of activities in grades K-4, all students should develop understanding of

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environments

DEVELOPING STUDENT UNDERSTANDING

During the elementary grades, children build understanding of biological concepts through direct experience with living things, their life cycles, and their habitats. These experiences emerge from the sense of wonder and natural interests of children who ask questions such as: "How do plants get food? How many different animals are there? Why do some animals eat other animals? What is the largest plant? Where did the dinosaurs go?" An understanding of the characteristics of organisms, life cycles of organisms, and of the complex interactions among all components of the natural environment begins with questions such as these and an understanding of how individual organisms maintain and continue life. Making sense of the way organisms live in their environments will develop some understanding of the diversity of life and how all living organisms depend on the living and nonliving environment for survival. Because the child's world at grades K-4 is closely associated with the home, school, and immediate environment, the study of

organisms should include observations and interactions within the natural world of the child. The experiences and activities in grades K-4 provide a concrete foundation for the progressive development in the later grades of major biological concepts, such as evolution, heredity, the cell, the biosphere, interdependence, the behavior of organisms, and matter and energy in living systems.

Children's ideas about the characteristics of organisms develop from basic concepts of living and nonliving. Piaget noted, for instance, that young children give anthropomorphic explanations to organisms. In lower elementary grades, many children associate "life" with any objects that are active in any way. This view of life develops into one in which movement becomes the defining characteristic. Eventually children incorporate other concepts, such as eating, breathing, and reproducing to define life. As students have a variety of experiences with organisms, and subsequently develop a knowledge base in the life sciences, their anthropomorphic attributions should decline.

In classroom activities such as classification, younger elementary students generally use mutually exclusive rather than hierarchical categories. Young children, for example, will use two groups, but older children will use several groups at the same time. Students do not consistently use classification schemes similar to those used by biologists until the upper elementary grades.

As students investigate the life cycles of organisms, teachers might observe that young children do not understand the continuity of life from, for example, seed to seedling or larvae to pupae to adult. But teachers will notice that by second grade, most students know that children resemble their parents. Students can also differentiate learned from inherited characteristics. However, students might hold some naive thoughts about inheritance, including the belief that traits are inherited from only one parent, that certain traits are inherited exclusively from one parent or the other, or that all traits are simply a blend of characteristics from each parent.

Young children think concretely about individual organisms. For example, animals are associated with pets or with animals kept in a zoo. The idea that organisms depend on their environment (including other organisms in some cases) is not well developed in young children. In grades K-4, the focus should be on establishing the primary association of organisms with their environments and the secondary ideas of dependence on various aspects of the environment and of behaviors that help various animals survive. Lower elementary students can understand the food link between two organisms.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

THE CHARACTERISTICS OF ORGANISMS

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.
- Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.
- The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.

LIFE CYCLES OF ORGANISMS

- Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms.
- Plants and animals closely resemble their parents.
- Many characteristics of an organism are inherited from the parents of the organism, but other characteristics result from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation.

ORGANISMS AND THEIR ENVIRONMENTS

- All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.
- An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce, and others die or move to new locations.
- All organisms cause changes in the environment where they live. Some of these changes are detrimental to the organism or other organisms, whereas others are beneficial.
- Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms.

Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades K-4, all students should develop an understanding of

- Properties of earth materials
- Objects in the sky
- Changes in earth and sky

DEVELOPING STUDENT UNDERSTANDING

Young children are naturally interested in everything they see around them--soil, rocks, streams, rain, snow, clouds, rainbows, sun, moon, and stars. During the first years of school, they should be encouraged to observe closely the objects and materials in their environment, note their properties, distinguish one from another and develop their own explanations of how things become the way they are. As children become more familiar with their world, they can be guided to observe changes, including cyclic changes, such as night and day and the seasons; predictable trends, such as growth and decay, and less consistent changes, such as weather or the appearance of meteors. Children should have opportunities to observe rapid changes, such as the movement of water in a stream, as well as gradual changes, such as the erosion of soil and the change of the seasons.

Children come to school aware that earth's surface is composed of rocks, soils, water, and living organisms, but a closer look will help them identify many additional properties of earth materials. By carefully observing and describing the properties of many rocks, children will begin to see that some rocks are made of a single substance, but most are made of several substances. In later grades, the substances can be identified as minerals. Understanding rocks and minerals should not be extended to the study of the source of the rocks, such as sedimentary, igneous, and metamorphic, because the origin of rocks and minerals has little meaning to young children.

Playgrounds and nearby vacant lots and parks are convenient study sites to observe a variety of earth materials. As students collect rocks and observe vegetation, they will become aware that soil varies from place to place in its color, texture, and reaction to water. By planting seeds in a variety of soil samples, they can compare the effect of different soils on plant growth. If they revisit study sites regularly, children will develop an understanding that earth's surface is constantly changing. They also can simulate some changes, such as erosion, in a small tray of soil or a stream table and compare their observations with photographs of similar, but larger scale, changes.

By observing the day and night sky regularly, children in grades K-4 will learn to identify sequences of changes and to look for patterns in these changes. As they observe changes, such as the movement of an object's shadow during the course of a day, and the positions of the sun and the moon, they will find the patterns in these movements. They can draw the moon's shape for each evening on a calendar and

then determine the pattern in the shapes over several weeks. These understandings should be confined to observations, descriptions, and finding patterns. Attempting to extend this understanding into explanations using models will be limited by the inability of young children to understand that earth is approximately spherical. They also have little understanding of gravity and usually have misconceptions about the properties of light that allow us to see objects such as the moon. (Although children will say that they live on a ball, probing questions will reveal that their thinking may be very different.)

Students can discover patterns of weather changes during the year by keeping a journal. Younger students can draw a daily weather picture based on what they see out a window or at recess; older students can make simple charts and graphs from data they collect at a simple school weather station.

Emphasis in grades K-4 should be on developing observation and description skills and the explanations based on observations. Younger children should be encouraged to talk about and draw what they see and think. Older students can keep journals, use instruments, and record their observations and measurements.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PROPERTIES OF EARTH MATERIALS

- Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.
- Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.
- Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time.

OBJECTS IN THE SKY

- The sun, moon, stars, clouds, birds, and airplanes all have properties, locations, and movements that can be observed and described.
- The sun provides the light and heat necessary to maintain the temperature of the earth.

CHANGES IN THE EARTH AND SKY

- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.
- Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle that lasts about a month.

Science and Technology

CONTENT STANDARD E:
As a result of activities in grades K-4, all students should develop

- Abilities of technological design
- Understanding about science and technology
- Abilities to distinguish between natural objects and objects made by humans

DEVELOPING STUDENT ABILITIES AND UNDERSTANDING

The science and technology standards connect students to the designed world, offer them experience in making models of useful things, and introduce them to laws of nature through their understanding of how technological objects and systems work.

This standard emphasizes developing the ability to design a solution to a problem and understanding the relationship of science and technology and the way people are involved in both. This standard helps establish design as the technological parallel to inquiry in science. Like the science as inquiry standard, this standard begins the understanding of the design process, as well as the ability to solve simple design problems.

Children in grades K-4 understand and can carry out design activities earlier than they can inquiry activities, but they cannot easily tell the difference between the two, nor is it important whether they can. In grades K-4, children should have a variety of educational experiences that involve science and technology, sometimes in the same activity and other times separately. When the activities are informal and open, such as building a balance and comparing the weight of objects on it, it is difficult to separate inquiry from technological design. At other times, the distinction might be clear to adults but not to children.

Children's abilities in technological problem solving can be developed by firsthand experience in tackling tasks with a technological purpose. They also can study technological products and systems in their world--zippers, coat hooks, can openers,

bridges, and automobiles. Children can engage in projects that are appropriately challenging for their developmental level--ones in which they must design a way to fasten, move, or communicate. They can study existing products to determine function and try to identify problems solved, materials used, and how well a product does what it is supposed to do. An old technological device, such as an apple peeler, can be used as a mystery object for students to investigate and figure out what it does, how it helps people, and what problems it might solve and cause. Such activities provide excellent opportunities to direct attention to specific technology--the tools and instruments used in science.

Suitable tasks for children at this age should have clearly defined purposes and be related with the other content standards. Tasks should be conducted within immediately familiar contexts of the home and school. They should be straightforward; there should be only one or two well-defined ways to solve the problem, and there should be a single, well-defined criterion for success. Any construction of objects should require developmentally appropriate manipulative skills used in elementary school and should not require time-consuming preparation and assembly.

Over the course of grades K-4, student investigations and design problems should incorporate more than one material and several contexts in science and technology. A suitable collection of tasks might include making a device to shade eyes from the sun, making yogurt and discussing how it is made, comparing two types of string to see which is best for lifting different objects, exploring how small potted plants can be made to grow as quickly as possible, designing a simple system to hold two objects together, testing the strength of different materials, using simple tools, testing different designs, and constructing a simple structure. It is important also to include design problems that require application of ideas, use of communications, and implementation of procedures--for instance, improving hall traffic at lunch and cleaning the classroom after scientific investigations.

Experiences should be complemented by study of familiar and simple objects through which students can develop observation and analysis skills. By comparing one or two obvious properties, such as cost and strength of two types of adhesive tape, for example, students can develop the abilities to judge a product's worth against its ability to solve a problem. During the K-4 years, an appropriate balance of products could come from the categories of clothing, food, and common domestic and school hardware.

A sequence of five stages--stating the problem, designing an approach, implementing a solution, evaluating the solution, and communicating the problem, design, and solution--provides a framework for planning and for specifying learning outcomes. However, not every activity will involve all of those stages, nor must any particular sequence of stages be followed. For example, some activities might begin by identifying a need and progressing through the stages; other activities might involve only evaluating existing products.

GUIDE TO THE CONTENT STANDARD

Fundamental abilities and concepts that underlie this standard include

ABILITIES OF TECHNOLOGICAL DESIGN

IDENTIFY A SIMPLE PROBLEM. In problem identification, children should develop the ability to explain a problem in their own words and identify a specific task and solution related to the problem.**[See Content Standard A (grades K-4)]**

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

IMPLEMENTING PROPOSED SOLUTIONS. Children should develop abilities to work individually and collaboratively and to use suitable tools, techniques, and quantitative measurements when appropriate. Students should demonstrate the ability to balance simple constraints in problem solving.

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

COMMUNICATE A PROBLEM, DESIGN, AND SOLUTION. Student abilities should include oral, written, and pictorial communication of the design process and product. The communication might be show and tell, group discussions, short written reports, or pictures, depending on the students' abilities and the design project.

UNDERSTANDING ABOUT SCIENCE AND TECHNOLOGY

- People have always had questions about their world. Science is one way of answering questions and explaining the natural world.
- People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems.
- Scientists and engineers often work in teams with different individuals doing different things that contribute to the results. This understanding focuses primarily on teams working together and secondarily, on the combination of scientist and engineer teams.
- Women and men of all ages, backgrounds, and groups engage in a variety of scientific and technological work.

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

ABILITIES TO DISTINGUISH BETWEEN NATURAL OBJECTS AND OBJECTS MADE BY HUMANS

- Some objects occur in nature; others have been designed and made by people to solve human problems and enhance the quality of life.
- Objects can be categorized into two groups, natural and designed.

Science in Personal and Social Perspectives

CONTENT STANDARD F:
As a result of activities in grades K-4, all students should develop understanding of

- **Personal health**
- **Characteristics and changes in populations**
- **Types of resources**
- **Changes in environments**
- **Science and technology in local challenges**

DEVELOPING STUDENT UNDERSTANDING

Students in elementary school should have a variety of experiences that provide initial understandings for various science-related personal and societal challenges. Central ideas related to health, populations, resources, and environments provide the foundations for students' eventual understandings and actions as citizens. Although the emphasis in grades K-4 should be on initial understandings, students can engage in some personal actions in local challenges related to science and technology.

Teachers should be aware of the concepts that elementary school students have about health. Most children use the word "germs" for all microbes; they do not generally use the words "virus" or "bacteria," and when they do, they do not understand the difference between the two. Children generally attribute all illnesses to germs without distinction between contagious and noncontagious diseases and without understanding of organic, functional, or dietary diseases. Teachers can expect students to exhibit little understanding of ideas, such as different origins of disease, resistance to infection, and prevention and cure of disease.

Children link eating with growth, health, strength, and energy, but they do not understand these ideas in detail. They understand connections between diet and health and that some foods are nutritionally better than others, but they do not necessarily know the reasons for these conclusions.

By grades 3 and 4, students regard pollution as something sensed by people and know that it might have bad effects on people and animals. Children at this age usually do not consider harm to plants as part of environmental problems; however, recent media attention might have increased students awareness of the importance of trees in the environment. In most cases, students recognize pollution as an environmental issue, scarcity as a resource issue, and crowded classrooms or schools as population problems. Most young students conceive of these problems as isolated issues that can be solved by dealing with them individually. For example, pollution can be solved by cleaning up the environment and producing less waste, scarcity can be solved by using less, and crowding can be solved by having fewer students in class or school. However, understanding the interrelationships is not the priority in elementary school.

Central ideas related to health, populations, resources, and environments provide the foundations for students' eventual understandings and actions as citizens.

As students expand their conceptual horizons across grades K-12, they will eventually develop a view that is not centered exclusively on humans and begin to recognize that individual actions accumulate into societal actions. Eventually, students must recognize that society cannot afford to deal only with symptoms: The causes of the problems must be the focus of personal and societal actions.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PERSONAL HEALTH

- Safety and security are basic needs of humans. Safety involves freedom from danger, risk, or injury. Security involves feelings of confidence and lack of anxiety and fear. Student understandings include following safety rules for home and school, preventing abuse and neglect, avoiding injury, knowing whom to ask for help, and when and how to say no.
- Individuals have some responsibility for their own health. Students should engage in personal care--dental hygiene, cleanliness, and exercise--that will maintain and improve health. Understandings include how communicable diseases, such as colds, are transmitted and some of the body's defense mechanisms that prevent or overcome illness.
- Nutrition is essential to health. Students should understand how the body uses food and how various foods contribute to health. Recommendations for

good nutrition include eating a variety of foods, eating less sugar, and eating less fat.
- Different substances can damage the body and how it functions. Such substances include tobacco, alcohol, over-the-counter medicines, and illicit drugs. Students should understand that some substances, such as prescription drugs, can be beneficial, but that any substance can be harmful if used inappropriately.

CHARACTERISTICS AND CHANGES IN POPULATIONS

- Human populations include groups of individuals living in a particular location. One important characteristic of a human population is the population density--the number of individuals of a particular population that lives in a given amount of space.
- The size of a human population can increase or decrease. Populations will increase unless other factors such as disease or famine decrease the population.

TYPES OF RESOURCES

- Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population.
- Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety.**[See Content Standard D (grades K-4)]**
- The supply of many resources is limited. If used, resources can be extended through recycling and decreased use.

CHANGES IN ENVIRONMENTS

- Environments are the space, conditions, and factors that affect an individual's and a population's ability to survive and their quality of life.**[See Content Standard C (grades K-4)]**
- Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans.
- Some environmental changes occur slowly, and others occur rapidly. Students should understand the different consequences of changing environments in small increments over long periods as compared with changing environments in large increments over short periods.

SCIENCE AND TECHNOLOGY IN LOCAL CHALLENGES

- People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people.
- Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world.

History and Nature of Science

CONTENT STANDARD G:
As a result of activities in grades K-4, all students should develop understanding of

- Science as a human endeavor

DEVELOPING STUDENT UNDERSTANDING

Beginning in grades K-4, teachers should build on students' natural inclinations to ask questions and investigate their world. Groups of students can conduct investigations that begin with a question and progress toward communicating an answer to the question. For students in the early grades, teachers should emphasize the experiences of investigating and thinking about explanations and not overemphasize memorization of scientific terms and information. Students can learn some things about scientific inquiry and significant people from history, which will provide a foundation for the development of sophisticated ideas related to the history and nature of science that will be developed in later years. Through the use of short stories, films, videos, and other examples, elementary teachers can introduce interesting historical examples of women and men (including minorities and people with disabilities) who have made contributions to science. The stories can highlight how these scientists worked--that is, the questions, procedures, and contributions of diverse individuals to science and technology. In upper elementary grades, students can read and share stories that express the theme of this standard--science is a human endeavor.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

SCIENCE AS A HUMAN ENDEAVOR

- Science and technology have been practiced by people for a long time.
- Men and women have made a variety of contributions throughout the history of science and technology.

- Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.
- Many people choose science as a career and devote their entire lives to studying it. Many people derive great pleasure from doing science.

Science Content Standards: 5-8

Science as Inquiry

CONTENT STANDARD A:
As a result of activities in grades 5-8, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

DEVELOPING STUDENT ABILITIES AND UNDERSTANDING

Students in grades 5-8 should be provided opportunities to engage in full and in partial inquiries. In a full inquiry students begin with a question, design an investigation, gather evidence, formulate an answer to the original question, and communicate the investigative process and results. In partial inquiries, they develop abilities and understanding of selected aspects of the inquiry process. Students might, for instance, describe how they would design an investigation, develop explanations based on scientific information and evidence provided through a classroom activity, or recognize and analyze several alternative explanations for a natural phenomenon presented in a teacher-led demonstration.

Students in grades 5-8 can begin to recognize the relationship between explanation and evidence. They can understand that background knowledge and theories guide the design of investigations, the types of observations made, and the interpretations

of data. In turn, the experiments and investigations students conduct become experiences that shape and modify their background knowledge.

With an appropriate curriculum and adequate instruction, middle-school students can develop the skills of investigation and the understanding that scientific inquiry is guided by knowledge, observations, ideas, and questions. Middle-school students might have trouble identifying variables and controlling more than one variable in an experiment. Students also might have difficulties understanding the influence of different variables in an experiment--for example, variables that have no effect, marginal effect, or opposite effects on an outcome.

Teachers of science for middle-school students should note that students tend to center on evidence that confirms their current beliefs and concepts (i.e., personal explanations), and ignore or fail to perceive evidence that does not agree with their current concepts. It is important for teachers of science to challenge current beliefs and concepts and provide scientific explanations as alternatives.

Several factors of this standard should be highlighted. The instructional activities of a scientific inquiry should engage students in identifying and shaping an understanding of the question under inquiry. Students should know what the question is asking, what background knowledge is being used to frame the question, and what they will have to do to answer the question. The students' questions should be relevant and meaningful for them. To help focus investigations, students should frame questions, such as "What do we want to find out about . . .?", "How can we make the most accurate observations?", "Is this the best way to answer our questions?" and "If we do this, then what do we expect will happen?"

Students in grades 5-8 can begin to recognize the relationship between explanation and evidence.

The instructional activities of a scientific inquiry should involve students in establishing and refining the methods, materials, and data they will collect. As students conduct investigations and make observations, they should consider questions such as "What data will answer the question?" and "What are the best observations or measurements to make?" Students should be encouraged to repeat data-collection procedures and to share data among groups.

In middle schools, students produce oral or written reports that present the results of their inquiries. Such reports and discussions should be a frequent occurrence in science programs. Students' discussions should center on questions, such as "How should we organize the data to present the clearest answer to our question?" or "How should we organize the evidence to present the strongest explanation?" Out of the

discussions about the range of ideas, the background knowledge claims, and the data, the opportunity arises for learners to shape their experiences about the practice of science and the rules of scientific thinking and knowing.

The language and practices evident in the classroom are an important element of doing inquiries. Students need opportunities to present their abilities and understanding and to use the knowledge and language of science to communicate scientific explanations and ideas. Writing, labeling drawings, completing concept maps, developing spreadsheets, and designing computer graphics should be a part of the science education. These should be presented in a way that allows students to receive constructive feedback on the quality of thought and expression and the accuracy of scientific explanations.

This standard should not be interpreted as advocating a "scientific method." The conceptual and procedural abilities suggest a logical progression, but they do not imply a rigid approach to scientific inquiry. On the contrary, they imply codevelopment of the skills of students in acquiring science knowledge, in using high-level reasoning, in applying their existing understanding of scientific ideas, and in communicating scientific information. This standard cannot be met by having the students memorize the abilities and understandings. It can be met only when students frequently engage in active inquiries.

GUIDE TO THE CONTENT STANDARD

Fundamental abilities and concepts that underlie this standard include

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

IDENTIFY QUESTIONS THAT CAN BE ANSWERED THROUGH SCIENTIFIC INVESTIGATIONS. Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.

DESIGN AND CONDUCT A SCIENTIFIC INVESTIGATION. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

USE APPROPRIATE TOOLS AND TECHNIQUES TO GATHER, ANALYZE, AND INTERPRET DATA. The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.

DEVELOP DESCRIPTIONS, EXPLANATIONS, PREDICTIONS, AND MODELS USING EVIDENCE. Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description--providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

THINK CRITICALLY AND LOGICALLY TO MAKE THE RELATIONSHIPS BETWEEN EVIDENCE AND EXPLANATIONS. Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.

RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND PREDICTIONS. Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.

COMMUNICATE SCIENTIFIC PROCEDURES AND EXPLANATIONS. With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations

USE MATHEMATICS IN ALL ASPECTS OF SCIENTIFIC INQUIRY. Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.

UNDERSTANDINGS ABOUT SCIENTIFIC INQUIRY

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some

involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Physical Science

CONTENT STANDARD B:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

DEVELOPING STUDENT UNDERSTANDING

In grades 5-8, the focus on student understanding shifts from properties of objects and materials to the characteristic properties of the substances from which the materials are made. In the K-4 years, students learned that objects and materials can be sorted and ordered in terms of their properties. During that process, they learned that some properties, such as size, weight, and shape, can be assigned only to the object while other properties, such as color, texture, and hardness, describe the materials from which objects are made. In grades 5-8, students observe and measure characteristic properties, such as boiling points, melting points, solubility, and simple chemical changes of pure substances and use those properties to distinguish and separate one substance from another.

Students usually bring some vocabulary and primitive notions of atomicity to the science class but often lack understanding of the evidence and the logical arguments that support the particulate model of matter. Their early ideas are that the particles have the same properties as the parent material; that is, they are a tiny piece of the substance. It can be tempting to introduce atoms and molecules or improve students' understanding of them so that particles can be used as an explanation for the properties of elements and compounds. However, use of such terminology is premature for these students and can distract from the understanding that can be gained from focusing on the observation and description of macroscopic features of substances and of physical and chemical reactions. At this level, elements and compounds can be defined operationally from their chemical characteristics, but few students can comprehend the idea of atomic and molecular particles.

In grades 5-8, students observe and measure characteristic properties, such as boiling and melting points, solubility, and simple chemical changes of pure substances, and use those properties to distinguish and separate one substance from another.

The study of motions and the forces causing motion provide concrete experiences on which a more comprehensive understanding of force can be based in grades 9-12. By using simple objects, such as rolling balls and mechanical toys, students can move from qualitative to quantitative descriptions of moving objects and begin to describe the forces acting on the objects. Students' everyday experience is that friction causes all moving objects to slow down and stop. Through experiences in which friction is reduced, students can begin to see that a moving object with no friction would continue to move indefinitely, but most students believe that the force is still acting if the object is moving or that it is "used up" if the motion stops. Students also think that friction, not inertia, is the principle reason objects remain at rest or require a force to move. Students in grades 5-8 associate force with motion and have difficulty understanding balanced forces in equilibrium, especially if the force is associated with static, inanimate objects, such as a book resting on the desk.

The understanding of energy in grades 5-8 will build on the K-4 experiences with light, heat, sound, electricity, magnetism, and the motion of objects. In 5-8, students begin to see the connections among those phenomena and to become familiar with the idea that energy is an important property of substances and that most change involves energy transfer. Students might have some of the same views of energy as they do of force--that it is associated with animate objects and is linked to motion. In addition, students view energy as a fuel or something that is stored, ready to use, and

gets used up. The intent at this level is for students to improve their understanding of energy by experiencing many kinds of energy transfer.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PROPERTIES AND CHANGES OF PROPERTIES IN MATTER

- A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
- Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. In chemical reactions, the total mass is conserved. Substances often are placed in categories or groups if they react in similar ways; metals is an example of such a group.
- Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.

MOTIONS AND FORCES

- The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph
- An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.
- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

TRANSFER OF ENERGY

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
- Heat moves in predictable ways, flowing from warmer objects to cooler ones, until both reach the same temperature.
- Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.

- Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.
- In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.
- The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

Life Science

CONTENT STANDARD C:
As a result of their activities in grades 5-8, all students should develop understanding of

- Structure and function in living systems
- Reproduction and heredity
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

DEVELOPING STUDENT UNDERSTANDING

In the middle-school years, students should progress from studying life science from the point of view of individual organisms to recognizing patterns in ecosystems and developing understandings about the cellular dimensions of living systems. For example, students should broaden their understanding from the way one species lives in its environment to populations and communities of species and the ways they interact with each other and with their environment. Students also should expand their investigations of living systems to include the study of cells. Observations and investigations should become increasingly quantitative, incorporating the use of computers and conceptual and mathematical models. Students in grades 5-8 also have the fine-motor skills to work with a light microscope and can interpret accurately what they see, enhancing their introduction to cells and microorganisms and establishing a foundation for developing understanding of molecular biology at the high school level.

Some aspects of middle-school student understanding should be noted. This period of development in youth lends itself to human biology. Middle-school students can develop the understanding that the body has organs that function together to maintain life. Teachers should introduce the general idea of structure-function in the context of human organ systems working together. Other, more specific and concrete examples, such as the hand, can be used to develop a specific understanding of structure-function in living systems. By middle-school, most

students know about the basic process of sexual reproduction in humans. However, the student might have misconceptions about the role of sperm and eggs and about the sexual reproduction of flowering plants. Concerning heredity, younger middle-school students tend to focus on observable traits, and older students have some understanding that genetic material carries information.

Students understand ecosystems and the interactions between organisms and environments well enough by this stage to introduce ideas about nutrition and energy flow, although some students might be confused by charts and flow diagrams. If asked about common ecological concepts, such as community and competition between organisms, teachers are likely to hear responses based on everyday experiences rather than scientific explanations. Teachers should use the students' understanding as a basis to develop the scientific understanding.

Understanding adaptation can be particularly troublesome at this level. Many students think adaptation means that individuals change in major ways in response to environmental changes (that is, if the environment changes, individual organisms deliberately adapt).

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

STRUCTURE AND FUNCTION IN LIVING SYSTEMS

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- All organisms are composed of cells--the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.
- Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.

- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

REPRODUCTION AND HEREDITY

- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.
- In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually--the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

REGULATION AND BEHAVIOR

- All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.
- Regulation of an organism's internal environment involves sensing the internal environment and changing physiological activities to keep conditions within the range required to survive.
- Behavior is one kind of response an organism can make to an internal or environmental stimulus. A behavioral response requires coordination and communication at many levels, including cells, organ systems, and whole organisms. Behavioral response is a set of actions determined in part by heredity and in part from experience.
- An organism's behavior evolves through adaptation to its environment. How a species moves, obtains food, reproduces, and responds to danger are based in the species' evolutionary history.

POPULATIONS AND ECOSYSTEMS

- A population consists of all individuals of a species that occur together at a given place and time. All populations living together and the physical factors with which they interact compose an ecosystem.
- Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers--they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.
- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs.
- The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increase at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem.

DIVERSITY AND ADAPTATIONS OF ORGANISMS

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.
- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the earth no longer exist.

Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

DEVELOPING STUDENT UNDERSTANDING

A major goal of science in the middle grades is for students to develop an understanding of earth and the solar system as a set of closely coupled systems. The idea of systems provides a framework in which students can investigate the four major interacting components of the earth system--geosphere (crust, mantle, and core), hydro-sphere (water), atmosphere (air), and the biosphere (the realm of all living things). In this holistic approach to studying the planet, physical, chemical, and biological processes act within and among the four components on a wide range of time scales to change continuously earth's crust, oceans, atmosphere, and living organisms. Students can investigate the water and rock cycles as introductory examples of geophysical and geochemical cycles. Their study of earth's history provides some evidence about co-evolution of the planet's main features--the distribution of land and sea, features of the crust, the composition of the atmosphere, global climate, and populations of living organisms in the biosphere.

By plotting the locations of volcanoes and earthquakes, students can see a pattern of geological activity. Earth has an outermost rigid shell called the lithosphere. It is made up of the crust and part of the upper mantle. It is broken into about a dozen rigid plates that move without deforming, except at boundaries where they collide. Those plates range in thickness from a few to more than 100 kilometers. Ocean floors are the tops of thin oceanic plates that spread outward from midocean rift zones; land surfaces are the tops of thicker, less-dense continental plates.

Because students do not have direct contact with most of these phenomena and the long-term nature of the processes, some explanations of moving plates and the evolution of life must be reserved for late in grades 5-8. As students mature, the concept of evaporation can be reasonably well understood as the conservation of matter combined with a primitive idea of particles and the idea that air is real. Condensation is less well understood and requires extensive observation and instruction to complete an understanding of the water cycle.

The understanding that students gain from their observations in grades K-4 provides the motivation and the basis from which they can begin to construct a model that explains the visual and physical relationships among earth, sun, moon, and the solar system. Direct observation and satellite data allow students to conclude that earth is a moving, spherical planet, having unique features that distinguish it from other planets in the solar system. From activities with trajectories and orbits and using the earth-sun-moon system as an example, students can develop the understanding that gravity is a ubiquitous force that holds all parts of the solar system together. Energy from the sun transferred by light and other radiation is the primary energy source for processes on earth's surface and in its hydrosphere, atmosphere, and biosphere.

By grades 5-8, students have a clear notion about gravity, the shape of the earth, and the relative positions of the earth, sun, and moon. Nevertheless, more than half of the students will not be able to use these models to explain the phases of the moon, and correct explanations for the seasons will be even more difficult to achieve.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

STRUCTURE OF THE EARTH SYSTEM

- The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.
- Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions
- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
- Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers, with each having a different chemical composition and texture.
- Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground.
- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.
- The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.
- Clouds, formed by the condensation of water vapor, affect weather and climate.
- Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans holds a large amount of heat.
- Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

EARTH'S HISTORY

- The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past. earth history is also influenced by occasional catastrophes, such as the impact of an asteroid or comet.
- Fossils provide important evidence of how life and environmental conditions have changed.

EARTH IN THE SOLAR SYSTEM

- The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.
- Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
- Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth's surface and explains the phenomena of the tides.
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.

Science and Technology

CONTENT STANDARD E:
As a result of activities in grades 5-8, all students should develop

- Abilities of technological design
- Understandings about science and technology

DEVELOPING STUDENT ABILITIES AND UNDERSTANDING

Students in grades 5-8 can begin to differentiate between science and technology, although the distinction is not easy to make early in this level. One basis for understanding the similarities, differences, and relationships between science and technology should be experiences with design and problem solving in which students can further develop some of the abilities introduced in grades K-4. The understanding of technology can be developed by tasks in which students have to design something and also by studying technological products and systems.

In the middle-school years, students' work with scientific investigations can be complemented by activities in which the purpose is to meet a human need, solve a

human problem, or develop a product rather than to explore ideas about the natural world. The tasks chosen should involve the use of science concepts already familiar to students or should motivate them to learn new concepts needed to use or understand the technology. Students should also, through the experience of trying to meet a need in the best possible way, begin to appreciate that technological design and problem solving involve many other factors besides the scientific issues.

In the middle-school years, students' work with scientific investigations can be complemented by activities that are meant to meet a human need, solve a human problem, or develop a product...

Suitable design tasks for students at these grades should be well-defined, so that the purposes of the tasks are not confusing. Tasks should be based on contexts that are immediately familiar in the homes, school, and immediate community of the students. The activities should be straightforward with only a few well-defined ways to solve the problems involved. The criteria for success and the constraints for design should be limited. Only one or two science ideas should be involved in any particular task. Any construction involved should be readily accomplished by the students and should not involve lengthy learning of new physical skills or time-consuming preparation and assembly operations.

During the middle-school years, the design tasks should cover a range of needs, materials, and aspects of science. Suitable experiences could include making electrical circuits for a warning device, designing a meal to meet nutritional criteria, choosing a material to combine strength with insulation, selecting plants for an area of a school, or designing a system to move dishes in a restaurant or in a production line.

Such work should be complemented by the study of technology in the students' everyday world. This could be achieved by investigating simple, familiar objects through which students can develop powers of observation and analysis--for example, by comparing the various characteristics of competing consumer products, including cost, convenience, durability, and suitability for different modes of use. Regardless of the product used, students need to understand the science behind it. There should be a balance over the years, with the products studied coming from the areas of clothing, food, structures, and simple mechanical and electrical devices. The inclusion of some nonproduct-oriented problems is important to help students understand that technological solutions include the design of systems and can involve communication, ideas, and rules.

The principles of design for grades 5-8 do not change from grades K-4. But the complexity of the problems addressed and the extended ways the principles are applied do change.

GUIDE TO THE CONTENT STANDARD

Fundamental abilities and concepts that underlie this standard include

ABILITIES OF TECHNOLOGICAL DESIGN

IDENTIFY APPROPRIATE PROBLEMS FOR TECHNOLOGICAL DESIGN. Students should develop their abilities by identifying a specified need, considering its various aspects, and talking to different potential users or beneficiaries. They should appreciate that for some needs, the cultural backgrounds and beliefs of different groups can affect the criteria for a suitable product

DESIGN A SOLUTION OR PRODUCT. Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints--such as cost, time, trade-offs, and materials needed--and communicate ideas with drawings and simple models.

IMPLEMENT A PROPOSED DESIGN. Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.

EVALUATE COMPLETED TECHNOLOGICAL DESIGNS OR PRODUCTS. Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications.

COMMUNICATE THE PROCESS OF TECHNOLOGICAL DESIGN. Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation.

UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY

- Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks,

and provide benefits. Many different people in different cultures have made and continue to make contributions to science and technology.

- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.
- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
- Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Science in Personal and Social Perspectives

CONTENT STANDARD F:
As a result of activities in grades 5-8, all students should develop understanding of

- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

DEVELOPING STUDENT UNDERSTANDING

Due to their developmental levels and expanded understanding, students in grades 5-8 can undertake sophisticated study of personal and societal challenges. Building on the foundation established in grades K-4, students can expand their study of health and establish linkages among populations, resources, and environments; they can develop an understanding of natural hazards, the role of technology in relation to personal and societal issues, and learn about risks and personal decisions. Challenges emerge from the knowledge that the products, processes, technologies and inventions of a society can result in pollution and environmental degradation and can involve some level of risk to human health or to the survival of other species.

The study of science-related personal and societal challenges is an important endeavor for science education at the middle level. By middle school, students begin to realize that illness can be caused by various factors, such as microorganisms, genetic predispositions, malfunctioning of organs and organ-systems, health habits, and environmental conditions. Students in grades 5-8 tend to focus on physical more than mental health. They associate health with food and fitness more than with other factors such as safety and substance use. One very important issue for teachers in grades 5-8 is overcoming students' perceptions that most factors related to health are beyond their control.

Students often have the vocabulary for many aspects of health, but they often do not understand the science related to the terminology. Developing a scientific understanding of health is a focus of this standard. Healthy behaviors and other aspects of health education are introduced in other parts of school programs.

By grades 5-8, students begin to develop a more conceptual understanding of ecological crises. For example, they begin to realize the cumulative ecological effects of pollution. By this age, students can study environmental issues of a large and abstract nature, for example, acid rain or global ozone depletion. However, teachers should challenge several important misconceptions, such as anything natural is not a pollutant, oceans are limitless resources, and humans are indestructible as a species.

Although students in grades 5-8 have some awareness of global issues, teachers should challenge misconceptions, such as anything natural is not a pollutant, oceans are limitless resources, and humans are indestructible as a species.

Little research is available on students' perceptions of risk and benefit in the context of science and technology. Students sometimes view social harm from technological failure as unacceptable. On the other hand, some believe if the risk is personal and voluntary, then it is part of life and should not be the concern of others (or society). Helping students develop an understanding of risks and benefits in the areas of health, natural hazards--and science and technology in general--presents a challenge to middle-school teachers.

Middle-school students are generally aware of science-technology-society issues from the media, but their awareness is fraught with misunderstandings. Teachers should begin developing student understanding with concrete and personal examples that avoid an exclusive focus on problems.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

PERSONAL HEALTH

- Regular exercise is important to the maintenance and improvement of health. The benefits of physical fitness include maintaining healthy weight, having energy and strength for routine activities, good muscle tone, bone strength, strong heart/lung systems, and improved mental health. Personal exercise, especially developing cardiovascular endurance, is the foundation of physical fitness.
- The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions.
- The use of tobacco increases the risk of illness. Students should understand the influence of short-term social and psychological factors that lead to tobacco use, and the possible long-term detrimental effects of smoking and chewing tobacco.
- Alcohol and other drugs are often abused substances. Such drugs change how the body functions and can lead to addiction.
- Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.
- Sex drive is a natural human function that requires understanding. Sex is also a prominent means of transmitting diseases. The diseases can be prevented through a variety of precautions.
- Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air.

POPULATIONS, RESOURCES, AND ENVIRONMENTS

- When an area becomes overpopulated, the environment will become degraded due to the increased use of resources.
- Causes of environmental degradation and resource depletion vary from region to region and from country to country.

NATURAL HAZARDS

- Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides,

wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids.
- Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.
- Natural hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

RISKS AND BENEFITS

- Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.
- Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
- Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits.
- Important personal and social decisions are made based on perceptions of benefits and risks.

SCIENCE AND TECHNOLOGY IN SOCIETY

- Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.
- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
- Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science

and technology have contributed enormously to economic growth and productivity among societies and groups within societies.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.
- Scientists and engineers have ethical codes requiring that human subjects involved with research be fully informed about risks and benefits associated with the research before the individuals choose to participate. This ethic extends to potential risks to communities and property. In short, prior knowledge and consent are required for research involving human subjects or potential damage to property.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

Science and technology have advanced through the contributions of many different people in different cultures at different times in history.

History and Nature of Science

CONTENT STANDARD G:
As a result of activities in grades 5-8, all students should develop understanding of

- Science as a human endeavor
- Nature of science
- History of science

DEVELOPING STUDENT UNDERSTANDING

Experiences in which students actually engage in scientific investigations provide the background for developing an understanding of the nature of scientific inquiry, and will also provide a foundation for appreciating the history of science described in this standard.

The introduction of historical examples will help students see the scientific enterprise as more philosophical, social, and human. Middle-school students can thereby develop a better understanding of scientific inquiry and the interactions

between science and society. In general, teachers of science should not assume that students have an accurate conception of the nature of science in either contemporary or historical contexts.

To develop understanding of the history and nature of science, teachers of science can use the actual experiences of student investigations, case studies, and historical vignettes. The intention of this standard is not to develop an overview of the complete history of science. Rather, historical examples are used to help students understand scientific inquiry, the nature of scientific knowledge, and the interactions between science and society.

GUIDE TO THE CONTENT STANDARD

Fundamental concepts and principles that underlie this standard include

SCIENCE AS A HUMAN ENDEAVOR

- Women and men of various social and ethnic backgrounds--and with diverse interests, talents, qualities, and motivations--engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity--as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

NATURE OF SCIENCE

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.
- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.

- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

Students should understand the difference between scientific and other questions and what science and technology can and cannot reasonably contribute to society.

HISTORY OF SCIENCE

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.
- In historical perspective, science has been practiced by different individuals in different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted.

National Arts Standards

Grades 1-4

1. Content Standard: Understanding and applying media,techniques, and processes

   Achievement Standard: Students
   a. know the differences between materials, techniques, and processes
   b. describe how different materials, techniques, and processes

cause different responses
c. use different media, techniques, and processes to communicate ideas, experiences, and stories
d. use art materials and tools in a safe and responsible manner

2. Content Standard:Using knowledge of *structures and functions

Achievement Standard:Students
a. know the differences among visual characteristics and purposes of art in order to convey ideas
b. describe how different *expressive features and *organizational principles cause different responses
c. use visual structures and functions of art to communicate ideas

3. Content Standard:Choosing and evaluating a range of subject matter, symbols and ideas

Achievement Standard:Students
a. explore and understand prospective content for works of art
b. select and use subject matter, symbols, and ideas to communicate meaning

4. Content Standard:Understanding the visual arts in relation to history and cultures

Achievement Standard:Students
a. know that the visual arts have both a history and specific relationships to various cultures
b. identify specific works of art as belonging to particular cultures, times, and places
c. demonstrate how history, culture, and the visual arts can influence each other in making and studying works of art

5. Content Standard:Reflecting upon and *assessing the characteristics and merits of their work and the work of others

Achievement Standard:Students
a. understand there are various purposes for creating works of visual art
b. describe how people's experiences influence the development of specific artworks
c. understand there are different responses to specific artworks

6. Content Standard:Making connections between visual arts and other

disciplines

Achievement Standard:Students
a. understand and use similarities and differences between characteristics of the visual arts and other arts disciplines
b. identify connections between the visual arts and other disciplines in the curriculum

Grades 5-8

Content Standard 1

Understanding and applying media, techniques, and processes

Achievement Standard

- Students select media, techniques, and processes; analyze what makes them effective or not effective in communicating ideas; and reflect upon the effectiveness of their choices
- Students intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas

Content Standard 2

Using knowledge of structures and functions

Achievement Standard

- Students generalize about the effects of visual structures and functions and reflect upon these effects in their own work
- Students employ organizational structures and analyze what makes them effective or not effective in the communication of ideas
- Students select and use the qualities of structures and functions of art to improve communication of their ideas

Content Standard 3

Choosing and evaluating a range of subject matter, symbols, and ideas

Achievement Standard

- Students integrate visual, spatial, and temporal concepts with content to communicate intended meaning in their artworks
- Students use subjects, themes, and symbols that demonstrate knowledge of contexts, values, and aesthetics that communicate intended meaning in artworks

Content Standard 4

Understanding the visual arts in relation to history and cultures

Achievement Standard

- Students know and compare the characteristics of artworks in various eras and cultures
- Students describe and place a variety of art objects in historical and cultural contexts
- Students analyze, describe, and demonstrate how factors of time and place (such as climate, resources, ideas, and technology) influence visual characteristics that give meaning and value to a work of art

Content Standard 5

Reflecting upon and assessing the characteristics and merits of their work and the work of others

Achievement Standard

- Students compare multiple purposes for creating works of art
- Students analyze contemporary and historic meanings in specific artworks through cultural and aesthetic inquiry
- Students describe and compare a variety of individual responses to their own artworks and to artworks from various eras and cultures

Content Standard 6

Making connections between visual arts and other disciplines

Achievement Standard

- Students compare the characteristics of works in two or more art forms that share similar subject matter, historical periods, or cultural context
- Students describe ways in which the principles and subject matter of other disciplines taught in the school are interrelated with the visual arts

Grades 9-12

Content Standard 1

Understanding and applying media, techniques, and processes

Achievement Standard

Proficient:

- Students apply media, techniques, and processes with sufficient skill, confidence, and sensitivity that their intentions are carried out in their artworks
- Students conceive and create works of visual art that demonstrate an understanding of how the communication of their ideas relates to the media, techniques, and processes

Advanced:

- Students communicate ideas regularly at a high level of effectiveness in at least one visual arts medium
- Students initiate, define, and solve challenging visual arts problems independently using intellectual skills such as analysis, synthesis, and evaluation

Content Standard 2

Using knowledge of structures and functions

Achievement Standard

Proficient:

- Students demonstrate the ability to form and defend judgments about the characteristics and structures to accomplish commercial, personal, communal, or other purposes of art
- Students evaluate the effectiveness of artworks in terms of organizational structures and functions
- Students create artworks that use organizational principles and functions to solve specific visual arts problems

Advanced:

- Students demonstrate the ability to compare two or more perspectives about the use of organizational principles and functions in artwork and to defend personal evaluations of these perspectives
- Students create multiple solutions to specific visual arts problems that demonstrate competence in producing effective relationships between structural choices and artistic functions

Content Standard 3

Choosing and evaluating a range of subject matter, symbols, and ideas

Achievement Standard

Proficient:

- Students reflect on how artworks differ visually, spatially, temporally, and functionally, and describe how these are related to history and culture
- Students apply subjects, symbols, and ideas in their artworks and use the skills gained to solve problems in daily life

Advanced:

- Students describe the origins of specific images and ideas and explain why they are of value in their artwork and in the work of others
- Students evaluate and defend the validity of sources for content and the manner in which subject matter, symbols, and images are used in the students' works and in significant works by others

Content Standard 4

Understanding the visual arts in relation to history and cultures

Achievement Standard

Proficient:

- Students differentiate among a variety of historical and cultural contexts in terms of characteristics and purposes of works of art
- Students describe the function and explore the meaning of specific art objects within varied cultures, times, and places
- Students analyze relationships of works of art to one another in terms of history, aesthetics, and culture, justifying conclusions made in the analysis and using such conclusions to inform their own art making

Advanced:

- Students analyze and interpret artworks for relationships among form, context, purposes, and critical models, showing understanding of the work of critics, historians, aestheticians, and artists
- Students analyze common characteristics of visual arts evident across time and among cultural/ethnic groups to formulate analyses, evaluations, and interpretations of meaning

Content Standard 5

Reflecting upon and assessing the characteristics and merits of their work and the work of others

Achievement Standard

Proficient:

- Students identify intentions of those creating artworks, explore the implications of various purposes, and justify their analyses of purposes in particular works
- Students describe meanings of artworks by analyzing how specific works are created and how they relate to historical and cultural contexts
- Students reflect analytically on various interpretations as a means for understanding and evaluating works of visual art

Advanced:

- Students correlate responses to works of visual art with various techniques for communicating meanings, ideas, attitudes, views, and intentions

Content Standard 6

Making connections between visual arts and other disciplines

Achievement Standard

Proficient:

- Students compare the materials, technologies, media, and processes of the visual arts with those of other arts disciplines as they are used in creation and types of analysis
- Students compare characteristics of visual arts within a particular historical period or style with ideas, issues, or themes in the humanities or sciences

Advanced:

- Students synthesize the creative and analytical principles and techniques of the visual arts and selected other arts disciplines, the humanities, or the sciences

Grades 5-8

1. Content Standard: Understanding and applying media, techniques, and processes

Achievement Standard:Students

a. select media, techniques, and processes; analyze what makes them effective or not effective in communicating ideas; and reflect upon the effectiveness of their choices
b. intentionally take advantage of the qualities and characteristics of *art media, techniques, and processes to enhance communication of their experiences and ideas

2. Content Standard: Using knowledge of *structures and functions

Achievement Standard:Students

a. generalize about the effects of visual structures and functions and reflect upon these effects in their own work
b. employ organizational structures and analyze what makes them effective or not effective in the communication of ideas
c. select and use the qualities of structures and functions of art to improve communication of their ideas

3. Content Standard:Choosing and evaluating a range of subject matter, symbols, and ideas

Achievement Standard:Students

a. integrate visual, spatial, and temporal concepts with content to communicate intended meaning in their artworks
b. use subjects, themes, and symbols that demonstrate knowledge of contexts, values, and aesthetics that communicate intended meaning in artworks

4. Content Standard:Understanding the visual arts in relation to history and cultures

Achievement Standard:Students

a. know and compare the characteristics of artworks in various eras and cultures
b. describe and place a variety of art objects in historical and cultural contexts
c. analyze, describe, and demonstrate how factors of time and place (such as climate, resources, ideas, and technology) influence visual characteristics that give meaning and value to a work of art

5. Content Standard:Reflecting upon and *assessing the characteristics and merits of their work and the work of others

Achievement Standard:Students

a. compare multiple purposes for creating works of art
b. analyze contemporary and historic meanings in specific artworks through cultural and aesthetic inquiry
c. describe and compare a variety of individual responses to their own artworks and to artworks from various eras and cultures

6. **Content Standard:Making connections between visual arts and other disciplines**

Achievement Standard:Students

a. compare the characteristics of works in two or more art forms that share similar subject matter, historical periods, or cultural context
b. describe ways in which the principles and subject matter of other disciplines taught in the school are interrelated with the visual arts