PART 8

Science and Technology for Children™

SIXTH-GRADE UNITS

Grade	Life, Earth, and Physical Sciences and Technology			
1	Organisms	Weather	Solids and Liquids	Comparing and Measuring
2	The Life Cycle of Butterflies	Soils	Changes	Balancing and Weighing
3	Plant Growth and Development	Rocks and Minerals	Chemical Tests	Sound
4	Animal Studies	Land and Water	Electric Circuits	Motion and Design
5	Microworlds	Ecosystems	Food Chemistry	Floating and Sinking
6	**Experiments with Plants**	**Measuring Time**	**Magnets and Motors**	**The Technology of Paper**

Sixth-Grade STC™ Units and the NSES (5–8)

National Science Education Standards for Grades 5–8	Experiments with Plants	Measuring Time	Magnets and Motors	The Technology of Paper
Science as Inquiry				
Abilities necessary to do scientific inquiry	●	●	●	●
Understandings about scientific inquiry	●	●	●	●
Physical Science				
Properties and changes of properties in matter			●	●
Motions and forces		●	●	
Transfer of energy		●	●	
Life Science				
Structure and function in living systems	●			
Reproduction and heredity	●			
Regulation and behavior	●		●	
Populations and ecosystems				
Diversity and adaptations of organisms	●			
Earth and Space Science				
Structure of the earth system				
Earth's history				
Earth in the solar system	●	●		
Science and Technology				
Abilities of technological design		●	●	●
Understandings about science and technology		●	●	●
Science in Personal and Social Perspectives				
Personal health			●	
Populations, resources, and environments				
Natural hazards				●
Risks and benefits				
Science and technology in society		●	●	●
History and Nature of Science				
Science as a human endeavor	●	●	●	●
Nature of science	●	●	●	●
History of science	●	●	●	●
Unifying Concepts and Processes				
Systems, order, and organization	●	●	●	
Evidence, models, and explanation	●	●	●	●
Constancy, change, and measurement	●	●	●	●
Evolution and equilibrium				
Form and function	●	●	●	●

Experiments with Plants

Narrative Summary

In this unit, students apply the knowledge and skills they have gained in earlier STC™ life science units to investigate some of the variables that affect plant growth and development. The main objective of the unit is to enable students to design and conduct a controlled experiment. They begin by studying the key variables that affect the life, health, and reproduction of the Wisconsin Fast Plant™ *(Brassica rapa)* and how they can manipulate these variables. Working in teams, students formulate a question about the plant and carry out a controlled experiment designed to answer that question. During the ensuing weeks, they observe the plants and record their data. Each team then shares its results with the class. Final activities entail germinating seeds that students have gathered from the plants and exploring tropisms.

Science Content

The key concepts of this life science unit are identifying, controlling, and manipulating variables in experimentation. The unit emphasizes how to formulate questions, use scientific methods and procedures, analyze findings, and report results. Students learn about the structure and function of plants and plant ecology, and they conduct experiments involving germination and tropism. The germination experiments are designed to help students appreciate the continuous nature of the life cycle. Throughout the unit, students are encouraged to find their own answers by experimenting and using resource materials. Mathematics in science, the abilities necessary to long-term scientific inquiry, and the nature of science are integral to this unit.

Assessment

This unit begins with a pre-unit assessment in which students brainstorm what they know about carrying out an experiment. To enable teachers to evaluate students' knowledge of controlling variables, students also discuss what it means to have a fair race. In the final part of the pre-unit assessment, students create labeled drawings of flowering plants. These activities are matched to a post-unit assessment following Lesson 16. Throughout the unit, students have several opportunities to evaluate and revise their own work in planned investigations before they design and carry out their own study. Their final project in written or oral form can be used as a culminating embedded assessment. Additional assessments at the end of the unit include a teacher's record chart of student progress. It allows teachers to assess each student's work products, concepts, and skills developed in the unit. Students can use a rating scale to conduct a self-assessment.

Goals for *Experiments with Plants*

In this unit, students plan and conduct experiments to determine how different variables affect the growth and seed production of rapid-cycling *Brassica rapa* (Wisconsin Fast Plants™). Their experiences introduce them to the following concepts, skills, and attitudes.

Concepts

- Plants need soil nutrients, light, and water.
- Plant growth is affected by the quantities of nutrients, light, and water available.
- Controlling variables enables the effect of each to be identified and studied.
- Flowering plants must be pollinated in order to produce seeds.
- Bees are effective pollinators.
- One seed has the potential to produce one plant.
- The number of seeds produced by a single plant is affected by such variables as nutrients, light, water, and the extent of pollination.
- The orientation of a plant's growth is affected by gravity and light.

Skills

- Planting and caring for plants.
- Predicting how changing one variable might affect the outcome of an experiment.
- Planning and conducting experiments in which variables are controlled.
- Observing, measuring, describing, and recording changes in plant growth.
- Communicating results through graphs, drawings, and group presentations.
- Interpreting and analyzing how different variables affect the growth and change of plants over time.
- Reflecting on experiences through writing and discussion.
- Reading and researching to learn more about plants.

Attitudes

- Developing an interest in investigating plant growth.
- Appreciating the need for careful and precise design of experiments.
- Appreciating the need for detailed recordkeeping during experimentation.
- Valuing scientific data that has been collected over time.

GRADE 6

Experiments with Plants

Fundamental Concepts and Principles Addressed (5–8)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific inquiry.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations.
- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science advances through legitimate skepticism.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for investigation, or develop new technologies to improve the collection of data.

Life Science

Structure and function of living systems

- Living systems demonstrate the complementary nature of structure and function.
- Cells carry on many functions needed to sustain life. Cells take in nutrients, which they use to provide energy or make the materials that a cell or an organism needs.

Reproduction and heredity

- Reproduction is characteristic of all living systems and is essential to the continuation of every species.
- Plants reproduce sexually with the egg and sperm produced in the flowers of flowering plants.
- 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.
- Behavior is one kind of response an organism can make to an internal or environmental stimulus.

Diversity and adaptations of organisms

- 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.

Earth and Space Science

Earth in the solar system

- The sun is a major source of energy for such phenomena as growth of plants.

History and Nature of Science

Science as a human endeavor

- Some scientists work in teams, others alone, but all communicate with one another.
- Science requires different abilities, human qualities, and habits of the mind.

Nature of science

- Scientists formulate and test their explanations of nature using observation, experiments, and models. Scientists change their ideas when led to do so by experimental evidence.
- 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, models, and explanations proposed by other scientists.

History of science

- Many individuals have contributed to the traditions of science.

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Constancy, change, and measurement

Form and function

Measuring Time

Narrative Summary

In the first part of this unit, "Keeping Time with the Sun and the Moon," students explore the use of natural phenomena, such as the phases of the moon, to keep time. In the second section, "Investigating Invented Clocks," students conduct experiments using some of the instruments that have been used to keep time throughout the centuries. They build and experiment with a water clock and investigate the characteristics of the pendulum. Finally, they apply what they have learned to assemble and evaluate a clock escapement and modify the device in order to make it more accurate. The unit provides students with an opportunity to learn how to measure time, to investigate machines, to explore concepts such as energy and motion, and to learn about the science of astronomy.

Science Content

Students engage in active and extended scientific inquiry as they construct water clocks; assemble, troubleshoot, and improve a working clock escapement; and engage in other activities related to measuring time. Students learn that time can be measured by observing the cycles of the sun and moon, and that mechanical devices can be constructed to measure intervals of time. The processes of technological design are addressed as students design, implement, evaluate, and communicate the processes of designing a water clock, pendulum, clock escapement, and one-minute timer. Classroom investigations enable them to appreciate that the accuracy of such instruments depends on an appropriate design. Students plan and conduct experiments involving controlled variables and experience the challenges typically faced by scientists and engineers. Reading selections and lesson objectives demonstrate the degree to which the history of timekeeping is integral to the unit.

Assessment

Assessment strategies include examination of matched student pre- and post-unit assessments, written student self-assessments, and student record sheets, graphs, and drawings, as well as observations of growth in scientific skills and contributions to class discussions. An embedded assessment in Lesson 16, in which students design and build their own one-minute timer, provides information on students' ability to apply what they have learned about timekeeping devices. Additional assessments at the end of the unit challenge students to respond, orally or in writing, to questions that are based on unit investigations of clocks and to make predictions about the changing appearance of the moon.

Goals for *Measuring Time*

In this unit, students investigate the history of timekeeping and experiment with various timekeeping devices. From their experiences, they are introduced to the following concepts, skills, and attitudes.

Concepts

- Time can be measured by observing the natural cycles of the sun and the moon.
- Shadows cast by the sun can be used to measure and predict the passage of time during a day.
- The phases of the moon follow a cycle that can be used to measure and predict the passage of time during a month.
- Mechanical devices can be constructed and used to measure specific intervals of time consistently.
- The accuracy of mechanical clocks is dependent on their design, the materials from which they are constructed, and their energy source.

Skills

- Observing and recording information about the natural cycles of the sun and the moon.
- Learning to plan and conduct experiments in which variables are controlled.
- Predicting and testing how changing a variable affects the outcome of an experiment.
- Interpreting test results to draw conclusions about how changing variables affects the outcome of an experiment.
- Communicating results through writing in notebooks; organizing information in charts, tables, and graphs; and discussion.
- Reading and researching science materials for more information.
- Applying previously learned concepts and skills to solve a problem.

Attitudes

- Developing an interest in exploring and investigating time.
- Recognizing the importance of repeating tests to validate results.
- Appreciating the advances people have made in measuring time and explaining natural phenomena.

GRADE 6

Measuring Time

Fundamental Concepts and Principles Addressed (5–8)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific inquiry.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations.
- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science advances through legitimate skepticism.
- 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.

Physical Science

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.

Transfer of energy

- Energy is a property of many substances. It is, for example, associated with mechanical motion.
- The sun is a major source of energy. 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 and consists of visible light, infrared, and ultraviolet radiation.

Earth and Space

Earth 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.

Science and Technology

Abilities of technological design

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

Understandings about science and technology

- Many different people in different cultures have made and continue to make contributions to science and technology.
- Perfectly designed solutions do not exist. All solutions have trade-offs.

Science in Personal and Social Perspectives

Science and technology in society

- Science influences society through its knowledge and world view.
- Technology influences society through its products and processes.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history.

History and Nature of Science

Science as a human endeavor

- Women and men of various backgrounds engage in the activities of science. Some scientists work in teams and some work alone, but all communicate extensively with others.
- Science requires different abilities. Science is very much a human endeavor, and the work of science relies on basic human qualities and scientific habits of mind.

Nature of science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.
- Different scientists 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.

History of science

- Many individuals have contributed to the traditions of science.
- In historical perspective, science has been practiced by different individuals in different cultures.
- 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.

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Constancy, change, and measurement

Form and function

Magnets and Motors

Narrative Summary

Magnets and Motors, which builds on the knowledge that students gained in the STC™ *Electric Circuits* unit, offers students the opportunity to explore the properties of magnets and the magnetic properties of electric currents. The unit includes information on the historical development of scientists' understanding of the use of magnetism, electricity, and electromagnetism. Students begin by studying magnets and making a compass. They then investigate the relationship between magnetism and electricity, as they explore the characteristics of switches and circuits. Finally, students experiment with three different motors. Applying their learning and experience, they dismantle, experiment with, and reassemble a manufactured motor.

Science Content

Students explore systems, organization, form, and function through their investigations of electric motors. These investigations encourage students to develop an appreciation for technology. The processes of technological design are addressed as students build and test a working electric generator. Physical science concepts include motions and forces and transfer of energy. Reading selections expand on the unit goals and cover such topics as how the earth's magnetic field affects some animals' movements. The unit mirrors the historical development of our understanding and use of magnetism, electricity, and electromagnetism and progresses through these phenomena in the same order that people discovered them—magnets and compasses, electricity from batteries, and electromagnetism (electromagnets, motors, and generators).

Assessment

Lesson 1 provides opportunities for students to take part in a pre-unit assessment brainstorming session and write and talk about what they already know about magnets and motors. It is complemented by a matched post-unit assessment. In several lessons, students produce models or diagrams or record observations that can be used to assess progress and understanding. An embedded assessment in Lesson 16 allows students to participate in an investigation that uses their new knowledge to produce a working electric generator. Additional assessments at the close of the unit include an investigation in which students build and demonstrate an electric current detector and a journal-writing exercise in which students express their ideas about how a spinning coil motor functions. Also included is an activity in which students are challenged to devise methods to measure the strength of a magnet. A teacher's record chart of student progress is included. It is a convenient way to keep a record of the progress of individual students and track the work students produce as well as the skills they develop.

Goals for *Magnets and Motors*

In this unit, students explore magnets, electromagnets, and motors. Through their experiences, students are introduced to the following concepts, skills, and attitudes.

Concepts

- Magnets attract and repel each other; this attracting and repelling can be used to cause motion.
- A compass can be constructed by suspending a magnet so that it is free to rotate.
- A compass will move in response to a magnet that is placed near it.
- An electric current moving through a wire produces magnetism; a coil of copper wire conducting an electric current becomes an electromagnet.
- A steel bolt placed inside a coil of wire conducting an electric current increases the strength of the electromagnet.
- A simple motor can be made from an electromagnet and a rotating armature.
- An electric current can be generated by placing a rotating coil of wire near a magnet.

Skills

- Observing, describing, and recording the results of experiments.
- Learning to plan and conduct experiments in which variables are controlled.
- Predicting and testing how changing a variable affects the outcome of an experiment.
- Interpreting the results of experiments to draw conclusions.
- Applying troubleshooting strategies to investigations with compasses, electromagnets, and motors.
- Reading and researching to learn more about electricity and motors.
- Communicating results through writing, drawing, and discussion.

Attitudes

- Developing an interest in experimenting with the technology of motors.
- Appreciating advances made in the use of magnets, electricity, and motors.
- Recognizing the importance of validating results through repeated testing.

GRADE 6

Magnets and Motors

Fundamental Concepts and Principles Addressed (5–8)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations use evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science advances through legitimate skepticism.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for investigation, or develop new technologies to improve the collection of data.

Physical Science

Properties and changes of properties in matter

- Substances, such as metals, are often placed in categories or groups if they react in similar ways.

Motions and forces

- The motion of an object can be described by its position, direction of motion, and speed.
- An object that is not being subjected to a force will continue to move at a constant speed.
- If more than one force acts on an object, then the forces will reinforce or cancel one another.

Transfer of energy

- Energy is a property of many substances and is associated with heat, light, electricity, and mechanical motion. Energy is transferred in many ways.
- Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.

Life Science

Regulation and behavior

- Behavior is one kind of response an organism can make to an internal or environmental stimulus. Behavioral response is a set of actions determined in part by heredity and in part from experience.

Science and Technology

Abilities of technological design

- Implement a proposed design.
- Evaluate completed technological designs or products.

Understandings about science and technology

- Many different people have made and continue to make contributions to science and technology.
- Science and technology are reciprocal.
- Perfectly designed solutions do not exist. All solutions have trade-offs.

Science in Personal and Social Perspectives

Personal health

- The potential for accidents and the existence of hazards impose 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 social and personal dimensions.

Science and technology in society

- Science influences society through its knowledge and world view.
- Technology influences society through its products and processes.
- Science and technology have advanced through contributions of different people at different times in history.

History and Nature of Science

Science as a human endeavor

- Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities.

Nature of science

- Scientists formulate and test their explanations of nature using observations, experiments, and models.
- It is normal for scientists in certain situations to differ with one another about the interpretation of evidence.
- It is part of scientific inquiry to evaluate the result of scientific investigations, experiments, observations, models, and explanations proposed by others.

History of science

- Many individuals have contributed to the traditions of science.
- 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 conclusions we currently take for granted.

Unifying Concepts and Processes

Systems, order, and organization

Evidence, models, and explanation

Constancy, change, and measurement

Form and function

The Technology of Paper

Narrative Summary

This unit gives students an opportunity to explore the properties of paper, to make paper by hand, and to understand how the properties of paper relate to how it is used. By testing six types of paper for smoothness, tear-resistance, opacity, water-resistance, and ink receptivity, students deepen their understanding of the relationship between the properties of a certain type of paper and its intended uses. Students read about industrial papermaking and explore hand papermaking. Using the class hand-papermaking process, students investigate the role of additives and of embedding and embossing in the creating of paper with a variety of properties. In a final activity, students apply their learning and experience to work through a four-step technological design process as they create their own recycled-paper product.

Science Content

This unit fosters understanding about science, technology, and society. Students design and conduct controlled tests and support their conclusions with evidence. The activities, which culminate in an extended opportunity to use a technological design process, challenge and broaden students' skills and abilities in these areas. This unit applies the history and nature of science to the study of common papers. Students investigate the physical properties and uses of paper and apply this knowledge to design, make, and evaluate their own recycled paper product, making scientific inquiry and technological design integral to this unit.

Assessment

Lesson 1 serves as a pre-unit assessment of students' knowledge of the properties and uses of paper and allows students to share what they know and want to know about paper. A matched post-unit assessment complements this activity. An embedded assessment in Lesson 5 gives students an opportunity to share test results and write a performance summary for the papers they have tested. A student self-assessment in Lesson 8 and another at the close of the unit allow students to reflect on their experiences. Embedded assessments, in which students apply their knowledge and skills by experimenting with the class paper-recycling process and designing and making their own recycled paper product, are also included. Additional assessments at the close of the unit invite students to apply the hand-papermaking and technological design process to a new situation, demonstrate their awareness of the value of product testing and of what constitutes a "fair test," and show their understanding of the design process.

Goals for *The Technology of Paper*

In this unit, students explore the properties of paper and the science of papermaking and apply these concepts through technological design. Through their experiences, students are introduced to the following concepts, skills, and attitudes.

Concepts

- Paper is made from plant fibers such as wood, cotton, and linen.
- Some properties of paper are how opaque, absorbent, tear-resistant, and smooth it is.
- The desired use of a paper determines the importance of, and quality specifications for, each property.
- Steps in hand and machine papermaking include preparing the fiber, beating and preparing pulp, sheet forming, pressing and drying, and finishing.
- People from different cultures have made and continue to make contributions to the science and technology of paper.
- Paper is a major renewable resource.
- Steps needed to make paper from recycled paper include collecting, sorting, removing contaminants, cleaning, and deinking.
- Additives are mixed with refined pulp to give paper special properties.
- Papermaking variations include embedding and embossing.
- Steps in technological design include identifying needs and opportunities, generating a design, planning and making the product, and testing and evaluating the product.
- Technological designs have constraints that can limit design choices. Constraints can include time and availability of materials.
- Design requirements specify how a designed object must perform.
- Product designers continually modify their design specifications in order to improve the products.

Skills

- Learning to perform class paper-property tests.
- Observing, describing, and recording test results and the structural, optical, and absorptive properties of paper.
- Collecting, analyzing, and drawing conclusions from data.
- Learning to plan and conduct tests with controlled variables.
- Predicting how changing a variable affects the outcome of a controlled test.
- Supporting conclusions with reasons that are based on observation and experience.
- Developing the ability to consider different aspects of a need by researching existing products and the desires of potential users.
- Applying previously learned concepts and skills to new situations, such as designing a paper product that meets a specific need.
- Studying products and systems to develop an understanding of technology.
- Generating and comparing design ideas in light of product requirements.

- Organizing and using materials and resources to test the properties of paper, recycle paper, and design and implement a plan to make a paper product.
- Evaluating products on the basis of how well they meet design requirements and suggesting modifications to better meet the products' design specifications.
- Communicating ideas and the process of technological design through writing and discussion.
- Reading to enhance understanding of the history and technology of papermaking.

Attitudes

- Developing an interest in exploring technological design through work with everyday materials.
- Developing an understanding of and appreciation for the importance of paper in our lives.
- Developing an understanding of and appreciation for the benefits of controlled product testing.
- Appreciating the importance of recycling paper.
- Appreciating how science is applied to solve practical problems.

The Technology of Paper

Fundamental Concepts and Principles Addressed (5–8)

Science as Inquiry

Abilities necessary to do scientific inquiry

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Mathematics is used in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations.
- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.
- Science advances through legitimate skepticism.
- 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.

Physical Science

Properties and changes of properties in matter

- A substance has characteristic properties.

Science and Technology

Abilities of technological design

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

Understandings about science and technology

- Scientific inquiry and technological design have similarities and differences.
- Many different people in different cultures have made and continue to make contributions to science and technology.
- Science and technology are reciprocal.
- Perfect design solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance.
- Technological designs have constraints.
- Technological solutions have intended benefits and unintended consequences.

Science in Personal and Social Perspectives

Natural hazards

- Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal.

Science and technology in society

- Technology influences society through its products and processes.
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, research institutes, and government agencies.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs.

History and Nature of Science

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.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry.

Nature of science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists.

History of science

- Many individuals have contributed to the traditions of science.
- In historical perspective, science has been practiced by different individuals in different cultures.
- 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.

Unifying Concepts and Processes

Evidence, models, and explanation

Constancy, change, and measurement

Form and function