Alignment of the Developmental Approaches in Science, Health and Technology (*DASH*)

and

Foundational Approaches in Science Teaching Programs (FAST)

with the National Science Education Standards

Grades 5–8

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FOREWORD

Alignment of the Developmental Approaches in Science, Health and Technology (*DASH*) and Foundational Approaches in Science Teaching (*FAST*) Programs with the National Science Education Standards

The *Foundational Approaches in Science Teaching* (*FAST*) program is a series of three inquiry science courses designed specifically for grades 6–10. *FAST* replicates the activities characteristic of the science disciplines by providing investigative experiences in the physical, biological, and earth sciences. Content is organized into three strands called physical science, ecology, and relational study. Relational study focuses on the interrelationships of the science disciplines and the interactions of science and society.

The goal of *FAST* is the development of a scientifically literate student who has 1) the background necessary for understanding the environmental concerns arising in our technological society, and 2) the foundational tools for further study in the sciences. The principal objectives of *FAST* are to develop thinking skills, laboratory skills, and knowledge of foundational concepts of the disciplines of science.

Developmental Approaches in Science, Health, and Technology (*DASH*), is an engaging K–6 inquiry-based program in science, health, and technology. *DASH* meets the National Science Education Standards and the American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* through ten learning clusters of activities specifically integrating science, health and technology. *DASH* is designed to articulate with language arts, mathematics, arts, history, and geography. Students with various backgrounds and learning styles master concepts and skills in contexts of authentic technological and scientific exploration, invention, and explanation providing models for thinking and problem solving.

Both *FAST* and *DASH* have been validated by the U.S. Department of Education's Program Effectiveness Panel and disseminated through the National Diffusion Network. They are also included in the U.S. Department of Education's *Promising Practices in Mathematics and Science* as meeting the standards for science reform in the United States.

The National Science Education Standards is a product of the National Research Council of the National Academy of Science. The standards are designed to enable the nation to achieve its goal of scientific literacy for all.

The following analysis describes how *FAST* and *DASH* address the recommended national standards for science education. The alignment of *DASH* draws only on the grade 5 and 6 portion of the K–6 program.

Alignment of *DASH* and *FAST* Programs with the National Science Education Standards

National Science Education Content Standards for Grades 5–8	Developmental Approaches in Science, Health and Technology (*DASH*) Grades 5 and 6 & Foundational Approaches in Science Teaching (*FAST*) (*FAST* 1, The Local Environment; *FAST* 2, Matter and Energy in the Biosphere; *FAST* 3, Change over Time)
1. 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, predications, and models using evidence; think critically and logically to make the relationships between evidence and explanations; recognize and analyze alternative explanations and prediction; communicate scientific procedures and explanations; use mathematics in all aspects of scientific inquiry.)	In *DASH* and *FAST* students conduct inquiry laboratory and field investigations about 80% of the time. As in science, values and attitudes such as the following are developed and established: knowing why it is important to keep honest, clear, and accurate records; knowing that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations; and knowing that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct. Students develop their own texts out of the investigations they do and the data they collect, analyze, interpret, and draw conclusions from. *DASH* employs a broad range of tools, many of which the students make, including enlargers such as the camera obscura, pin hole cameras, telescopes, and microscopes; impact measuring devices to measure the energy of moving objects; and the tools of photography and record keeping to preserve observations and measurements of slow progressing events. Throughout *DASH* students invent, design, make, and test laboratory tools and tools used in crafting products. Students develop all of their basic laboratory measurement skills in *FAST*. Students assemble and disassemble laboratory equipment used in their investigations. They invent and calibrate a wide variety of instruments needed in their investigations. In both *DASH* and *FAST* data tables and graphs are used extensively to analyze data and search for patterns and relationships. Students generate data from their own investigations and compare their findings with those of others. Students keep a log of their investigations and findings in their student notebooks which become their textbook.

1. Science as Inquiry (Continued)

	Communication through oral and written scientific reports and student seminars and debates form a central focus in both programs. Just as in science, communication is essential to students in constructing their knowledge of science. Library research is first introduced through the use of classroom references and later extended to the research literature relevant to student investigations that can be found in the library and in computer databases.
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.	Every *DASH* activity identifies a group of scientists, technologists, health workers, or others who normally work at the task that they are engaged in. The activities closely follow the investigative modes of the different disciplines and use similar means for collecting data, reasoning, and hypothesizing to make sense of the observations. Particularly in biology problems involving multiple variables, populations size, controls, experimental replication are constantly confronted by *DASH* students. Experiments are normally done collaboratively with group monitoring of the appropriateness of methodology. Throughout *FAST* students design and carry out their own investigations. Careful attention is paid to valid experimental design including the use of controls, replication of experimental results, and setting of proper standards. Scientists and how they worked are studied in the disciplines of astronomy, chemistry, physics, geophysics and organic chemistry. Students conduct actual investigations as physical scientists, ecologists, and technologists. *FAST* investigations rely on replication of data and group consensus on the interpretation of results. Specific examples of where students examine bias include the use of the coldwater potometer, replication in experimental design, and data collection on air and water quality in *FAST* 1. The selection of *DASH* activities has been guided by a recapitulationist notion that history provides a developmental sequence of the ideas of science, health services, and other technologies that can be used to guide the school curriculum. *DASH* students become inventors, designers, builders, testers, investigators, hypothesizers, experimenters, and interpreters of data as they reconstruct the human experience of science and technology in the context of the classroom. In this environment *DASH* is blind to gender, racial, or ethnic differences. This development of science and technology is an experience open to all human beings.

1. Science as Inquiry (Continued)

	DASH classes are encouraged to draw upon the community of present day professionals to exemplify the import of their inquiry. This allows students to see that these professionals are operating on the same knowledge base that they are experiencing and that once ideas are generated they become the property of the entire human community. Just as important, the use of community resources allows students to see and visualize the many work places of professionals. *DASH* students confront the ethical responsibilities that are inherent in dealing with animal populations form kindergarten, and these responsibilities are extended into their grade 6 activities. *FAST* investigations are taken from an historical approach. We have looked to the history of science for examples of how humans first dealt with foundational science concepts. In their investigations, students also examine how ideas have changed over time and the cumulative contributions of scientists worldwide. Specifically, the nature of the scientific enterprise is the focus of investigations of Dalton's Atomic Theory (*FAST* 2) and the *FAST* 3 sections on the history of astronomy, organic chemistry, plate tectonics, and human intervention in environments. Students are required to keep notebooks of their investigations. Their notebook is their science textbook in *FAST*.
• Mathematics is important in all aspects of scientific inquiry.	*DASH* uses a wide range of mathematical techniques, including graphing, intuitive geometry, arithmetic, decimals, negative and positive numbers, scaling, and multiple forms of measuring. Different techniques are called upon as needed. Often several different operations will be used by different class groups or individuals to analyze and/or display the same information. By allowing the students to seek their own techniques of display and analysis they quickly grasp the idea of an inherent equivalency of mathematical techniques to give meaning to their data. Graphing is used extensively in *FAST* as a tool to search for patterns and relationships. For example, students use graphs to find averages and compare with calculated means in comparing densities of substances. Measuring is an important part of mathematics and science. In *DASH* and *FAST* students learn basic skills in linear, area, volume, mass, temperature, density, energy, work, chromatography, astronomical, and other measurements.
• Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.	*DASH* students as scientists and technologists are encouraged to take advantage of the full range of instructive modes available to them. This begins with their own experience and experimentation, and embraces the knowledge found in reference works, and in the expertise of teachers, professionals, and others.

1. Science as Inquiry (Continued)

	DASH students are aware of the role of technology in science and they work at the tasks of instrument makers, crafters of devices necessary to carry out their experiments, and keepers of the records of their work. In *DASH* 6 students are periodically asked to deal with the moral, ethical, economic, and political issues of various dimensions of such a mission. The growth of technology and the subsequent impact on scientific knowledge is noted in such areas as the development of the balance (*FAST* 1), methods of handling gases (*FAST* 2), the history of plate tectonics, and the development of astronomy and astronomical instruments (*FAST* 3). Students build their own instruments for field mapping, weather measurement, air pollution studies, water quality studies, and astronomy. Design projects such as submarines, moving fluids project give students opportunities to solve practical problems through technology. These problems have multiple solutions, but solutions must be evaluated in terms of feasibility and human value.
• 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.	Throughout *DASH* and *FAST* students design and carry out their own investigations. Careful attention is paid to valid experimental design including the use of controls, replication of experimental results, and setting of proper standards.
• 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.	Scientists and how they work are studied in the disciplines of astronomy, chemistry, physics, geophysics and organic chemistry. Students conduct actual investigations as physical scientists, ecologists, and technologists. Specifically, the nature of the scientific enterprise is the focus of investigations of Dalton's Atomic Theory (*FAST* 2) and the *FAST* 3 sections on the history of astronomy, organic chemistry, plate tectonics, and human intervention in environments.
• 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.	Investigations are taken from an historical approach. We have looked to the history of science for examples of how humans first dealt with foundational science concepts. In their investigations, students also examine how ideas have changed over time and the cumulative contributions of scientists worldwide. Students are engaged in conducting inquiry investigations approximately 80% of the time. Class organization is in research teams in which students develop their own hypotheses, experimental designs, and explanations. The teacher's role is research director. Explanation must be supported by evidence and openly communicated to peer groups for support. Healthy skepticism is part of the learning environment. In this way, *FAST* replicates scientific inquiry.

1. Science as Inquiry (Continued)

	In addition to learning about the nature of science by doing scientific investigations, *FAST* also causes students to focus on the nature of science by embedding case studies of historical events. See particularly, *FAST* 2, Matter & Energy in the Biosphere, PS Unit 2, Evidence for an Atomic Theory and *FAST* 3, Change over Time, Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 7, Humans in the Environment.

2. Physical Science

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.	These concepts are developed in investigations in: *FAST* 1, The Local Environment—PS Unit 1, Introduction to the Properties of Matter; Unit 2, Change of State. *FAST* 2, Matter & Energy in the Biosphere—PS Unit 2, Evidences for an Atomic Theory; Unit 3. A Model of Matter. *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 3, The Changing Universe; Unit 4, Life on Earth. *DASH* introduces the nomenclature of atoms, molecules, and compounds. Bernoulli's dynamic atomic model of a gas is introduced in the description of the effects of temperature on air pressure. Its application is hypothesized to explain changes in state. In *DASH* 6 solution chemistry is studied in the formation of evaporative mineral deposits and the recovery of compounds from solutions. The idea of conservation of matter is hypothesized as a logical consequence of matter in a closed system such as a spacecraft.
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.	These concepts are developed in investigations in *FAST* 3, Change over Time—Unit 1, Force, Work and Energy; Unit 3, The Changing Universe. A highly sophisticated asymmetric balance with fixed and sliding counter balances is constructed in *DASH* 6 that has a sensitivity of 0.1 g, ±0.1 g at a cost under 50¢. The orbits of the planets are attributed to gravity starting in *DASH* 5. Magnetic and electrostatic forces are investigated in detail in *DASH* 6 and become the basis for the invention of various machines including communication devices and motors. Airfoil lift and rocket propulsion models are developed from Bernoulli's work. The orbital paths of spacecraft and satellites under the influence of gravity are studied in *DASH* .

2. Physical Science (Continued)

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.	These concepts are developed in investigations in: *FAST* 1, The Local Environment—PS Unit 3, Temperature and Heat. *FAST* 2, Matter & Energy in the Biosphere—PS Unit 1, Light and Heat; PS Unit 3, A Model of Matter; E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3, Cycling of Matter; RS Unit 1, Productivity Project. *FAST* 3, Change over Time—Unit 1, Force, Work and Energy; Unit 2, The Changing Earth; Unit 3, The Changing Universe; Unit 5, Continental Drift; Unit 7, Humans in the Environment. Energy is a major theme of *DASH* from grades K–6 and is a topic of special consideration in Cluster 8, Energy and Communication. Students also study the storage of energy as part of Conservation, Recycling, and Decomposition activities. Energy transformation is extensively investigated. Light, electricity, chemicals, friction, and mechanical energy are all investigated as ways of producing heat. In *DASH* 6 the emphasis is on transformation of light into heat and photosynthetic products; electricity and magnetism into mechanical energy, heat, light including radio and sound; chemical energy into electricity and motion; and gravitational energy into motion and heat. Heat transfer by particle collision is hypothesized in the study of Bernoulli's model of gases. Formation of currents in liquids and gases is investigated.

3. Life Science

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.	Cells are a topic of inquiry in *DASH* 5. Single cell organisms are observed with student constructed microscopes. Tissues are studied at the same time and organs are defined as body structures made of different tissues. Both animal and plant cells are studied along with the reproductive, energy producing, repair and growth, and nutrient reliance and waste producing requirements of cells. This informational base is reinforced in *DASH* 6 in studies of single-celled disease organisms, nutrition, aquaculture, and hydroponics. Water, protein, carbohydrate, mineral, fat, and vitamin components of cells are investigated. Examples: 5.3.4 Cells, 5.3.5 Cell Quiz, 5.5.2 Nutrients And Cells, 5.10.7 Making A Microscope *DASH* nutrition studies investigate the three primary functions of foods in the body-energy production, building and repair, and body regulation. In studies of the digestive tract the bodies processing of foods is studied from its entry into the mouth to the discharge of fecal waste.

3. Life Science (Continued)

• 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.	The process of breathing is first studied in grade 1 and continued through grade 6. The skin as a barrier against infection is first introduced in grade 2. As a barrier against disease it is further studied in investigations of sexually transmitted diseases in grade 5 and 6. The brain as a central information processor is introduced in grade 4. Its association with the senses is a focus in grades 5 and 6. Common, viral, bacterial, mold, and animal parasitic disease are investigated. Emphasis is on prevention, treatment, and long term health implications. Natural disease fighting mechanisms, chemical and cellular are included, as well as therapeutic methods of treatment. The hormonal system is discussed in regards to growth development and emotional states. Sensory organs and ways of enhancing sense reception through technology are studied. Optical devices, sound amplifiers, heat sensors, pressure measurement devices are made and operated. Structure and function at the organism and ecosystem levels are developed in investigations in: *FAST* 1, The Local Environment—E Unit 1, Plant Growth; E Unit 3, Animal Care; E Unit 4, Field Ecology *FAST* 2, Matter & Energy in the Biosphere—E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3, The Cycling of Matter. *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 6, Changing Ecosystems. *FAST* Human Biology Supplement (optional)
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.	The study of life developing from eggs and seed ova begin in *DASH* K where insect metamorphosis and plant growth are observed. Continuing observation is made of plants and insects throughout *DASH*. Developing embryos of frogs and fish are added in *DASH* 1–3. In *DASH* 4 development of the chick embryo is followed. Human reproduction is a focus of *DASH* 5. *DASH* 6 continues developmental studies centering on the problems of teen-age pregnancy. Likeness between parent organisms and offspring are studied in both animals and plants. In animals inherited behaviors are noted and distinguished from learned behaviors. These studies are extended to the students own parent-sibling group. *FAST* 1, The Local Environment—E Unit 1, Plant Growth; E Unit 3, Animal Care; E Unit 4, Field Ecology; *FAST* 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project; *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 6, Changing Ecosystems. *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 6, Changing Ecosystems.

3. Life Science (Continued)

• Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another. • Heredity 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.	*FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 6, Changing Ecosystems. *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 6, Changing Ecosystems.
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.	The inability of animals to manufacture their own food from the raw materials of nature is stressed from grades 1–6. Plants are observed to be producers of the food which some animals eat and those that do not eat plants are eaters of animals that do eat plants. Food and sunlight as a biological energy sources is amplified in activities starting in kindergarten. To emphasize our human need for energy students are introduced to the three functions of food: activation, regulation and fabrication. Foods are sorted into the principal or mixed contribution to those three functions. Other animals are found to use food to satisfy these same three functions. Human needs for secondary sources of warmth and how these have extended our capacity to live in inhospitable habitats are extensively studied. The essential character of light as a source of energy for plants is investigated from grade 2–6. *FAST* 1, The Living Environment—E Unit 1, Plant Growth; E Unit 3, Animal Care; E Unit 4, Field Ecology. *FAST* 2, Matter & Energy in the Biosphere—E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3, The Cycling of Matter. *FAST* 3, Change over Time—Unit 1, Life on Earth; Unit 6, Changing Ecosystems.

3. Life Science (Continued)

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 microorganisms are producers—they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem. • 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.	Field studies throughout *DASH* show that different plants have different environmental needs. This is systematically explored in the study of trees, shrubs, broad-leafed plants, and grasses in grade 5. Starting in kindergarten the students find that animals have three very different environments in which they can live—water, land, and sky; that to live in each of these environments requires special adaptations. The role of some insects as decomposers is extensively studied in the third grade composting unit and carries on through the sixth grade unit on worms. The interactions of plants and animals are investigated in the third grade biological control, pollination, and seed dispersal activities. The import of microorganisms in the digestion of animals is studied in grades 4 and 5. The interaction of plants in providing sun, shelter, and water conservation is studied in grade 5. The non-beneficial as well as predominantly beneficial role of microorganisms is a recurring theme from grades 3–6. This is dramatically brought out in studies of compost in grade 3, molds in grade 4, and disease and non-disease organisms in grades 5 and 6. *FAST* 1, The Local Environment—E Unit 4, Field Ecology; *FAST* 2, Matter & Energy in the Biosphere—PS Unit 1, Light and Heat; E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3, The Cycling of Matter *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment.

3. Life Science (Continued)

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.	*DASH* students spend considerable time out of doors investigating the organisms about the school, neighborhood, home and other environments. They make and use keys to identify organisms as well as making herbaria documenting the plants they find. They focus on the common and uncommon features that distinguish different groups of organisms. In grade 4 the students focus on identification of fungi, birds, and trees using standard field guides. They distinguish living from non-living things and identify characteristic requirements of life such as water, air, and nutrients. They find that these characteristics are not useful to separate plants from animals, or pines from birches. In *DASH* 6 studies of aquaculture and hydroponics land and aquatic plants, invertebrates, and fish are studied. This is accompanied by detailed studies of decomposers and soil builders. The uniqueness of virus, bacteria, and molds is observed and reflected upon in the light of earlier plant and animal dichotomies. *FAST* 1, The Local Environment—Ecology strand *FAST* 2, Matter & Energy in the Biosphere—Ecology strand *FAST* 3, Change over Time

4. Earth and Space Science

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 a 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.	Changes of state as part of the water cycle is introduced in *DASH* grade 3. Water vapor and its condensation as fog and ice melting and crystallization are studied in grades 3–6. Examples: 3.10.9 Rain In A Jar, 4.2.1 Rainfall, 4.2.2 Snowfall, 4.2.6 Humidity, 4.2.7 Clouds And Weather, 4.2.8 Storm Clouds, 5.2.1 Weather Station, 5.2.2 The Heat Index And The Hygrometer, 5.2.3 Weather And Its Prediction, 5.2.4 Fronts, 5.2.5 Clouds. Air and wind are studied in grades K–6. *DASH* students keep regular records of wind speed and direction as part of their weather studies. They engage in an intensive study of air and its properties and components in grades 4 and 6. Examples: 3.2.4 Wind, 3.8.1 Shadow, Light, And Bubbles, 3.8.2 Wind And Heat, 3.8.3 Wind Pulls And Pushes, 4.2.3 Wind Direction, 4.2.4 Wind Speed, 4.10.13 Air And Fire, 4.10.14 Fire And Oxygen, 4.10.15 Properties Of Gases, 5.2.1 Weather Station.

4. Earth and Space Science (Continued)

• 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 compositions of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.	Rocks and their properties are characterized in grades 4–6. Study of the nature of soil and its formation begins in grade 2 and continues through grade 6. Emphasized are both the inorganic and organic components of soil. Examples: 3.4.3 Watching Garden Soil, 3.4.4 Making Artificial Soil, 3.4.5 Testing Artificial Soil, 3.4.6 Soil And Water, 3.9.1 Making Compost, 3.9.2 Watching Compost, 3.9.3 Animals In Compost, 3.9.4 Using Compost, 4.10.4 Collecting Rocks, 4.10.5 Harness Of Rocks, 4.10.6 Specific Gravity, 4.10.7 Rocks And Sharp Edges, 4.10.11 Clay, 5.4.9 Roots, 5.4.10 Soil Conservation. *DASH* 6 caps studies of the geology and meteorology of the Earth by using them to provide models of the geology and meteorology of Mars as it is now and may exist in the future when it is terriformed to support life. *DASH* 6 continues studies of gravity and its role in holding together the solar system. Similarities in Earth's and Mars's axial rotation are studied to predict parallels in Mars's seasons and weather conditions before and after terriforming. Earth's moon phases have been studied in *DASH* K through 5 and are extended in *DASH* 6 to predictions about the surface of Mars and its moons. These concepts are developed in investigations in: *FAST* 1, The Local Environment—PS Unit 2, Change of State; PS Unit 3, Temperature and Heat; E Unit 2, The Physical Environment; RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management *FAST* 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project; RS 2, World Food Production *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment
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.	In *DASH*, the study of the erosion process of nature begins in grade 2 and continues through grade 6. Examples: 3.4.6 Soil And Water, 4.10.14 Collecting Rocks, 5.4.9 Roots, 5.4.10 Soil Conservation. In *DASH* 6 geologic forces on Earth are studied to reflect on geologic forces on Mars. Studied are regions of Mars with geologic formations produced by catastrophic conditions—volcanic eruption, subsidence, earthquakes and regions produced by gradual processes—uplift, erosion, sedimentation, evaporative deposition, and so forth. Rock formation from volcanism, sedimentation, and evaporation and metamorphism by heat and pressure are studied. The historic layering of sediments and volcanic flows is hypothesized. These concepts are further developed in *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems.

4. Earth and Space Science (Continued)

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 motions 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.	Astronomy is a major area of study in *DASH*. From Kindergarten the students follow the phases of the moon and the movement of other celestial bodies across the day and night sky. In grade 3 they are introduced to a simple planetarium housing the north circumpolar stars. In grade 4 the planetarium is expanded to include the stars of the zodiac. In grade 5 declinations and right ascensions are included. Seasonal movement of the stars and sum are followed as well as the wanderings of the planets. Examples: 3.2.9 Polar Constellations, 3.2.10 Venus, 4.2.17 Planetarium, 4.2.18 Using The Planetarium, 4.2.19 Planets, 5.7.2 Planetarium, 5.7.3 Mapping The Sky *DASH* students make their own telescopes in grade 5 and use them to study the moon, planets, and stars. With their scopes the moon is seen in greater detail and the Milky Way becomes a river of stars. Examples: 5.2.8 Moon Through A Telescope, 5.10.5 Making A Telescope, 5.10.6 Stabilizing The Telescope. Venus is studied beginning in grade 3 . Mars in added in grade 4. The other visible planets are added to their study in grade 5. The orbit of the moon around the earth is deduced from data on moon phases and eclipses in grade 4. The logic for a sun-centered solar system is worked out in grade 5 with the deduction that the earth and other planets are orbiting the sun contrary to commonsense observation of the apparent diurnal movements of the sun. Examples: 4.2.17 Planetarium, 4.2.18 Using The Planetarium, 4.2.19 Planets, 4.2.24 Moon Phases And The Sun, 4.2.25 Eclipses, 5.2.10 Path Of Celestial Bodies, 5.2.11 Models Of The Solar System, 5.7.2 Planetarium, 5.7.3 Mapping The Sky, 5.7.4 The North Pole, Equator, And Ecliptic, 5.7.5 Where Is The Earth?. Distance of heavenly bodies is investigated in grade 5. This includes study of relative brightness and size. Examples: 5.7.3 Mapping The Sky, 5.2.9 How Big And Far Away Is The Moon?, 5.2.10 Path Of Celestial Bodies. By *DASH* 6 they are ready to study a planet in detail, its climates, seasons, geography, geology, and to navigate to that planet. Throughout they rely upon use and modify the astronomical models developed previously. All this is kept alive by regular reports on astrophysical events as found in magazines and newspapers and posted on the Learning Calendar. These concepts are further developed in: *FAST* 2, Matter & Energy In the Biosphere—PS Unit 1, Light and Heat; E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3, The Cycling of Matter; RS Unit 1, Productivity Project; RS Unit 2, World Food Production *FAST* 3, Change over Time—Unit 1, Force, Work and Energy; Unit 2, The Changing Earth; Unit 3, The Changing Universe

5. 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)	Because *DASH* students are constantly inventing, designing, making, testing and modifying devices to satisfy various needs, they learn early that there are innumerable ways of technologically achieving such satisfaction. They constantly confront trade offs—quality vs. time expended, aesthetics vs. functionality, cost vs. quality. Design failure is not uncommon in *DASH* where students confront real construction problems. It becomes clear that technology requires time and patience in tinkering to make even the best of prototypes work. This is best exemplified in instrument making and in other *DASH* projects. *DASH* students frequently find that the solution to one problem leads to another—the new subdivision that becomes eroded in a heavy rain, the bird feeder that becomes a point for bird droppings, the break in the city water main that floods a city block. Student-made inventions and devices are analyzed for how well they work and for their impact on the environment and society. *FAST* design projects offer many opportunities to evaluate alternative solutions to problems. In Change over Time, students specifically study the interaction of technology and society from an historical perspective and in the present including such topics as population growth, energy and land use, and resource management. Decision making is practiced in a simulation called Ostrich Bay where students get to see the consequences of decision regarding the use of technologies. In *FAST* 1, design technologies are analyzed in studies of weather, air pollution, and water resource management. In *FAST* 2, students design efficient garden plots to maximize production and then analyze their designs in terms of the results obtained and environmental impact. In *FAST*, investigations of anomalies often result in failure of students' first attempts to solve them. For example, in measuring the heat from sunlight in *FAST* 2, the design flaws in initial devices and the need for standard measurements are identified by students. A return to this project is successful when knowledge of materials and skills gained in *FAST* investigations have been completed.

5. Science and Technology (Continued)

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 tradeoffs, 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.	*DASH* students as scientists and technologists are encouraged to take advantage of the full range of instructive modes available to them. This begins with their own experience and experimentation, and embraces the knowledge found in reference works, and in the expertise of teachers, professionals, and others. *DASH* students are aware of the role of technology in science and they work at the tasks of instrument makers, crafters of devices necessary to carry out their experiments, and keepers of the records of their work. In *DASH* 6 students are periodically asked to deal with the moral, ethical, economic, and political issues of various dimensions of such a mission. The growth of technology and the subsequent impact on scientific knowledge is noted in such areas as the development of the balance (*FAST* 1), methods of handling gases (*FAST* 2), the history of plate tectonics, and the development of astronomy and astronomical instruments (*FAST* 3). Students build their own instruments for field mapping, weather measurement, air pollution studies, water quality studies, and astronomy. The Relational Study strand in the *FAST* courses is designed to help students understand the relationships between science, technology, and society. Specific projects such as the submarine project, the weather balloon project, and the moving fluids project require students to apply the science they have been learning to technological designs. The Relational Study units in each course further expand on and explore these relationships. *FAST* 1, The Local Environment—RS Unit 1, Air Pollution; Unit 2, Water Resource Management *FAST* 2, Matter & Energy in the Biosphere—PS Unit 2, Evidence for an Atomic Theory; RS Unit 1, Productivity Project; RS Unit 2, World Food Production *FAST* 3, Change over Time—Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 7, Humans in the Environment

6. Science in Personal and Social Perspectives

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.	Physical and mental health are seen as intertwined in *DASH* lessons on human behavior. People's feelings are affected by their health and health is affected by feelings. Understanding the body's nutrient requirements is introduced in kindergarten and is progressively studied through grade 6. *DASH* students first classify foods as they are used for activation, regulation, or fabrication. In grade 4 they use the US Department of Agriculture's Nutritional Pyramid. Examples: 3.5.1 Food Selection, 3.5.2 Selecting Plants For The Garden, 3.5.3 Planning The Class Feast, 3.5.5 The Class Feast, 4.5.1 Nutrition Messages, 4.5.4 Food Groups, 4.5.5 Digestion Game, 4.5.6 Preserving Foods, 5.5.1 Nutrients, 5.5.2 Nutrients And Cells, 5.5.3 RDA And Food Labeling. Environmental poisons, alcohol, tobacco and recreationally used drugs are topics of extensive study beginning in grade 2. Both the physiological and social implications of their use are studied. Students keep separate class room SCRAP BOOKS of newspaper accounts of drugs, tobacco, and alcohol use and treatment. Examples: 3.4.1 Garden Invaders, 3.4.11 Controlling Insects, 3.6.5 Lung Model, 3.6.6 Lungs And Smoking, 3.6.12 Helpful Drugs, 3.6.13 Proper Drug Use, 4.6.7 Smoking And The Lungs, 4.6.8 Alcohol, Tobacco, And Drugs, 5.6.4 Alcohol, Tobacco, And Drugs, 5.6.5 Sexually Transmitted Diseases, 5.6.6 Sexually Transmitted Diseases, 5.6.7 Tobacco Quiz, 5.6.8 Smokers' Survey, 5.6.9 Ex-Smokers' Survey, 5.6.10 Smoking Laws, 5.6.11 Alcohol Quiz, 5.6.12 Alcohol Laws, 5.6.13 Chris's Story, 5.6.14 The Parents' Story, 5.6.15 Intoxication, 5.6.16 Drug Laws. *DASH* 6 investigates the caloric content of foods and has students devise diets to meet their personal age, sex, weight, and exercise patterns. Nutritional needs of developing teenagers are emphasized, with attention to the role of different nutrients in their body growth and regulation. Special attention is given to pregnant teenagers. Disease and the need for sanitation is stressed from K–6. Each year some aspect of the problem of disease transmission is studied. Virus, bacteria, protozoa, and disease producing microscopic insects are studied in grade 5 and 6 when sexually transmitted diseases become a focal point of investigation. Throughout there is an emphasis on the body's natural defenses and ways of enhancing those defenses. Examples: 3.6.10 Disease Transmission, 4.4.2 The Fungus Among Us. 5.6.5 Sexually Transmitted Diseases, 5.6.6 Sexually Transmitted Disease Quiz. Natural and acquired immunity as well as diseases that can be controlled by vaccines are studied in grade 5 and 6.

6. Science in Personal and Social Perspectives (Continued)

	Common, viral, bacterial, mold, and animal parasitic disease are investigated. Emphasis is on prevention, treatment, and long term health implications. Natural disease fighting mechanisms, such as antibodies, antitoxins, and white cells are included, as well as immunity due to natural infection and therapeutic methods such as vaccination, use of toxoids, antibiotics, and so forth. The Martian simulation keeps the students aware of the dangers of air, water, and soil contamination. Human emotions are studied through several vehicles. These include role playing, vignette analysis, and interpreting the content of a *DASH* Stories series. In role playing the students are involved in the creation and analysis of the problems. Multiple perceptions of feelings are evident and become the basis for insight in this emotional variable in their relationships with peers and family. Vignettes and novels create much the same experience through vicarious involvement. Examples: 4.1.5 Working Together, 4.1.9 Survival Game, 5.1.5 Working Together, 5.1.8 Friendship, 5.6.13 Chris's Story, 5.6.14 The Parents' Story. These issues are further addressed in the *FAST* Human Biology Supplement (optional). *FAST* 1, The Local Environment—RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management. *FAST* 2, Matter & Energy in the Biosphere—E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3. The Cycling of Matter.
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.	*FAST* 3, Change over Time—Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment *FAST* 1, The Local Environment—RS Unit 1, Air Pollution; Unit 2, Water Resource Management *FAST* 3, Change over Time—Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment.
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.	These issues are developed through investigations in the Relational Study strand of the *FAST* courses. *FAST* 1, The Local Environment—RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management *FAST* 2, Matter & Energy in the Biosphere—RS Unit 2, World Food Production *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment

6. Science in Personal and Social Perspectives (Continued)

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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.

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FAST 1, The Local Environment—RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management
FAST 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project; RS Unit 2, World Food Production
FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment

Systems analysis is introduced in *FAST* 2, Matter & Energy in the Biosphere and used throughout both *FAST* 2 and *FAST* 3.
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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.

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These concepts and issues are developed in the Relational Study strand of all three courses in *FAST* where the focus is on the interactions of science, technology and society. They are also a major focus of investigations in *FAST* 3, Change over Time.

The deep involvement of students with technology and the regular connecting of the work of the classroom with the technologies pursued in the world around them provide living examples of the place of technology in the culture they know.

The dynamics of a *DASH* class provide numerous opportunities for students to be involved in linking one invention with another. As students invent solutions to problems they are encouraged to share their ideas. As a result one idea is quickly embedded in many more.

By looking at the history of technology *DASH* students gain a sense of the immense difference between our modern technological wealth and the paucity of the available technological products of the past. Through science and technology news articles recorded on the *DASH* Learning Calendar and accounts in the Connections Book they see that much of the world does not yet have access to many of the material products of our culture.

In *DASH* technology is a vehicle to learning concepts that undergrid science. *DASH* students simultaneously confront engineering principles, scientific laws, and properties of materials. Safety, appearance, space occupied, time necessary for construction, cost, and the impact of failure are all considered in the design phase of projects. Similar concerns in the working world of technology and science are found in interviews with professionals as guest presenters at numerous points in the program.
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• 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.	Advantages and disadvantages are a common topic of newspaper articles posted on the Learning Calendar and observations made in the Connections Book. The relative environmental costs and benefits of chemical pesticides and biological controls are studied in agricultural activities. Other costs and benefits such as diseases associated with trash and pollution and the values of clean up; the waste of energy and material resources and their conservation or recycling are ongoing studies. Examples of *FAST* studies that focus on the feats of technology include Kepler's inventions and his interpretation of Brahe's data (*FAST* 3), techniques of analyzing matter used by early chemists (*FAST* 2 and *FAST* 3), and Galileo's and Newton's inventions (*FAST* 3). The impact of technology on the course of history is specifically included in *FAST* investigations on agricultural technology (*FAST* 2 and *FAST* 3), the Copernican revolution (*FAST* 3), and the role of technology in the scientific revolution over plate tectonics (*FAST* 3). Risk-benefit analysis is included in studies of slash and burn agriculture, energy resource use, population studies and limiting factors in the environment, the impact of fertilizers and pesticides, and case studies of population effects. Complexity of technological issues is the focus on studies of air pollution and water resource management (*FAST* 1), the productivity project and world food production (*FAST* 2), and energy/land use by humans past and present (*FAST* 3).

7. 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 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.	*DASH* and *FAST* involve all students in doing science. Investigations call for different roles, skills, and knowledge. Each *DASH* activity identifies the kinds of professionals who would engage in such work. Teachers are encouraged to have guest speakers talk with students about their jobs, training, salary, and professional obligations. In keeping with the goal of science for all students, *DASH* and *FAST* investigations are designed for full class participation. To achieve this, activities are designed to address differences in learning styles and modalities. They include opportunities to engage students with strengths in kinesthetic, spatial, logical-mathematical, linguistic, interpersonal, and intrapersonal modes of learning. Cooperative learning and grouping techniques allow teachers to organize the classroom for maximum use of peer teaching. These techniques cause greater focus on the work under study by all students. One of the goals is to get students to be self-actuated learners willing to pursue their natural curiosity to answer their own questions. Throughout they are asked to frame their own questions and seek answers. The classroom is designed to model the larger communities of the biological, earth, physical and social sciences; technologies; and health care services. Communication is essential since investigations are interconnected, often long term, and often the product of small groups of students. Intellectual honesty is held as a high virtue in the communities of technologists and science researchers in which students participate. Error is expected, accepted, and overcome by alternative contributions by the community or redoing an investigation or remaking a product. Records are kept as they are generated and changes are recorded as additional data with corresponding explanation. The classroom community of technologists and scientists is a community of reason. Ideas are presented based on interpreted experience and data and they are judged on the same basis. Through their own experimentation students come to understand that investigations are done for different purposes with different techniques and with different types of analyses. Emphasis throughout is on developing the habits of mind that characterize modern science.

7. History and Nature of Science (Continued)

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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.

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In *DASH* and *FAST* students develop a scientific world view by doing science—designing and carrying out experiments, collecting and analyzing data, and drawing conclusions based on evidence. Students respond to differences in data collected by looking for patterns and relationships, setting standards, examining the effects of human and instrument error, graphing data and looking for generalizations. Generalizations are based on data and consensus. For example, in the design of investigations such as the effect of scarification on seed germination and the effects of environmental conditions on plant propagation, students learn valid experimental design and analysis.

Definitions written in student books are reviewed and modified as new information is collected in investigations. A definition can always be revised as new information becomes available.

Actual data from earlier experiments are used to determine experimental relationships as for example the study of combining gaseous substances in the Literature of Chemistry section of *FAST* 2.

Ethical dilemmas are examined in topics such as population growth, energy sources and needs, human world food production, and decision making for the future.

Through doing their own inquiry investigations throughout the three courses in *FAST*, students experience the aspects of stable science that has withstood the tests of time and interpretation. In *FAST* 3, students are introduced to areas of science in which competing explanations based on the same data exist side by side. See for example, *FAST* 3, Change over Time—Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift

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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.

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These concepts are developed in investigations in:
FAST 2, Matter & Energy in the Biosphere and
FAST 3, Change over Time

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8. Unifying Concepts and Processes	
Systems, order, and organization	Systems is a common unifying theme throughout *FAST* 1, The Local Environment, *FAST* 2, Matter & Energy in the Biosphere, and *FAST* 3, Change over Time. *FAST* 2 and *FAST* 3 make extensive use of systems analysis diagrams to help organize thinking and make predictions about interactions of matter and energy. Similarly, order and organization are exemplified in investigating cause-and-effect relationships, atomic and kinetic molecular theories, cosmological theories to explain the origin and organization of the universe, trophic relationships among organisms in the environment, and exchanges of matter and energy. *DASH* students have wide-ranging experiences with systems and the interaction of parts. They deal with the human body as a system composed of organs, machines as systems composed of parts, the solar system composed of the sun, moon, planets, asteroids, ecosystems composed of living and non-living things, and classrooms as a social system composed of teachers and students. Order and organization—Tendencies to bring order and organization to their work are personal qualities nurtured throughout *DASH*. Students are caused to confront the need for order and organization in their conceptual and skill development, in the ways materials are used and stored, and the way their work environment operates. Ongoing conceptual organization of work is daily arrayed in the use of the Learning Calendar. Data on weather and astronomy are recorded and the day's instructional experience is systematic debriefing to list concepts and skills studied and practiced. Concept mapping and entries in the Working Dictionary regularly cause consideration of connectivity as an organizer of ideas. Throughout *DASH*, organization of work space, personal storage areas such as cubbies and desk compartments is the subject of invention. Notebooks and classroom records are intentionally organized for immediate and long-term retrieval. Safety and need for storage and work space motivate organization and storage of classroom materials. Students are made aware of the need for organization of time, space, and energy to carry out projects and the detailed organization necessary to consider in the technological environments of the school, home, and society. Order and organization are found in studies of natural environments and events. Order as sequence is found in meteorological, astronomical, and cycles of life. Structural organization in nature becomes most evident as the parts and systems of organisms are studied.

Evidence, models, and explanation	Evidence as in student-generated data and interpretation is the primary focus of the *FAST* program. There are no answers in the student book. Student-generated data provide the substance for small group and class discussion. Interpretation and explanation are a matter of class consensus, just as they are in science. The use and study of indirect evidence is introduced in *FAST* 2 with the search for evidence for atoms. It is continued in *FAST* 3 where students encounter competing explanations for continental drift, stellar evolution, biological evolution, and cosmological theories. A continuing major focus is on how do we know what we think we know. Constructing devices and other products is common throughout *DASH*. In major projects, models are made of final products on the assumption that experimentation on a miniature version or a graphic representation is far more efficient than rebuilding the final product after deficiency is found. Students also make models of body parts, the solar system, and the universal sky. *DASH* students are constantly communicating with each other, their teacher, and a wider audience of parents and interested outsiders. To do this they use a full range of modes of communication including geometric figures in geometric explanations of problems, number sequences in deciphering codes, graphs analysis and presentation of data, diagrams and sketches of things to be made and things observed, number lines in timelines and instrument scales, maps in planning projects, and projectional stories about what could have and might yet happen. Evidence and explanation—From the beginning of kindergarten students are involved in observing, describing, classifying, and generalizing about phenomena in the artificial and natural worlds around them. This evidentiary base becomes the grist for explanation of how things work. In the beginning, explanation is tested in the light of reasonableness—Does the explanation being made fit with the evidence we know? Over time the evidentiary process is a product of intentional experimental probing to test explanation. Almost all *DASH* activities provide the stuff of evidence. Many evoke generalization and explanation. The concept of model is introduced in *FAST* 1, The Local Environment in investigations of weather and the water cycle in the ecology strand and in investigations of heat energy in physical science. The concept is expanded in the relational study units on air pollution and water resource management. Models becomes a major organizing theme of *FAST* 2, Matter & Energy in the Biosphere (model of heat, model of light, model of matter, systems analysis models of producers, consumers, and decomposers) and *FAST* 3, Change over Time (model of heat, models of Earth, cosmological models, models of stellar evolution, models of organisms, molecular models, models of Earth change, models of ecosystems, and models of human interaction with ecosystems).

8. Unifying Concepts and Processes (Continued)

Change, constancy, and measurement	Measurement, computation, and estimation are integral parts of both *DASH* and *FAST*. Emphasis is placed on developing laboratory skills of measuring distance, mass, area, volume, temperature, time, rainfall, humidity, vapor pressure, transpiration, energy transfer, rates of change, heat, work, force, specific heat, solar constant, movement of the sun, moon, planets, and constellations, and so on. Students construct and calibrate many of their own instruments such as those for field mapping, measuring the solar constant, measuring forces, and many others. Human error, instrument, and observational error are considered in all measurement problems. Students quickly find that actual measurements are quite often slightly different, and the same measurement is seen slightly differently by different observers. *DASH* and *FAST* students are daily observers of change. They see change and constancy in common features of the events around them—in the growth of plants and animals and their own growth, in the decomposition and materials, in their constructing with materials, in their interpersonal relationships. They also see, handle, make, and use numerous things that have shapes that when viewed from different angles appear to be the same-spheres and circles, cubes and squares, and other geometric figures and organisms that mimic these geometries. Constancy and change are seen in studies of decomposition, human growth, and environmental surveys. Rhythm of change and rate of change are both inherent in many *DASH* studies. To give analyzable accounts of these kinds of change, measurements are constantly made. Investigations involving measurements of rhythm are found in studies of the phase of the moon, the movement of the sun along the ecliptic, the growth, maturity, and death of plants and animals. Rate studies include growth rates, speeds of vehicle, decomposition rates, and rates of heating. Constancy and change in physical and biological systems are developed in investigations in: *FAST* 1, The Local Environment—Unit 4, Field Ecology; *FAST* 2, Matter & Energy in the Biosphere—E Unit 3, The Cycling of Matter; RS Unit 1, Productivity Project; *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment. Constancy and change as represented in symbolic equations: *FAST* 2, Matter & Energy in the Biosphere—PS Unit 2, Evidence for an Atomic Theory; E Unit 1, Primary Production. Constancy and change in symmetry: *FAST* 2, Matter & Energy in the Biosphere—crystal growing; *FAST* 3, Change over Time—molecular models. Constancy and change in cycles: *FAST* 1, The Local Environment—life cycles, water cycle; *FAST* 2, Matter & Energy in the Biosphere—cycling of matter & flow of energy; *FAST* 3, Change over Time—geologic cycles, stellar life cycles, cosmological models, changing ecosystems, biological cycles.

8. Unifying Concepts and Processes (Continued)

Evolution and equilibrium	Evolution in the sense of evolving ordered and predictable change over time is a common experience in *DASH*. This is found in studies of seasonal change, life cycle changes including their own physiology, and astronomical and meteorological change. Evolution in the Darwinian sense is saved for the experience of grades 5–8. Equilibrium in the sense of balance is brought out in the making of metric balances. Balance within ecological systems is found in observation of classroom aquariums. Evolution of life: *FAST* 3, Change over Time—Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems. Evolution in physical systems: *FAST* 3, Change over Time—Unit 2, The Changing Earth; Unit 3, The Changing Universe; Unit 5, Continental Drift; Unit 7, Humans in the Environment.
Form and function	Form and function are called on in organizing categories of objects such as organisms and in the creation of definition. Kindergartners are introduced to the roles of form and function in definition in the *DASH* Focus Book, The Friendly Shape. Question about form and function are asked throughout *DASH*. *FAST* 3, Change over Time—Unit 4, Life on Earth, molecular structure and function; Unit 6, Changing Ecosystems, biological adaptations. *FAST* Human Biology Supplement (optional)

CURRICULUM RESEARCH & DEVELOPMENT GROUP

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