Alignment of the Foundational Approaches in Science Teaching Program (FAST)

with the National Science Education Standards

Grades 5–8

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FOREWORD

Alignment of the Foundational Approaches in Science Teaching Program (FAST) with the National Science Education Standards

Foundational Approaches in Science Teaching (FAST) is an inquiry, multidisciplinary program for grades 6–10. FAST is validated by the U.S. Department of Education's Program Effectiveness Panel and disseminated through the National Diffusion Network. It is also included in the U.S. Department of Education's *Promising Practices in Mathematics and Science*. Developmental funding was provided by the University of Hawaiʻi.

FAST meets the National Science Education Standards and the American Association for the Advancement of Science (AAAS) *Benchmarks for Science Literacy* through three one-year courses called: The Living Environment, Matter and Energy in the Biosphere, and Change over Time. Students with various backgrounds and learning styles master concepts and skills in contexts of authentic scientific exploration, invention, and explanation providing models for thinking and problem solving.

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 addresses the recommended national standards for science content.

Alignment of FAST with the National Science Education Standards

National Science Education Content Standards for Grades 5–8	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 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. 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 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. Communication through oral and written scientific reports and student seminars and debates form a central focus in FAST. Just as in science, communication is essential to students in constructing their knowledge of science. Library research is first introduced through the use of the FAST classroom library and later extended to the research literature relevant to student investigations that can be found in the library and in computer databases.

1. Science as Inquiry (Continued)

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.	Each FAST course is organized into three strands, physical science, ecology (including the biological and earth science content), and relational study. By investigating phenomena in each strand, students experience first hand how different disciplines of science go about generating new knowledge. One of the functions of the relational study strand is to focus on the kinds of inquiry that characterize each science discipline. 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. 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.
• Mathematics is important in all aspects of scientific inquiry.	Mathematics plays a central role in FAST beginning with initial investigations on buoyancy and density (FAST 1), study of Dalton's Atomic Theory (FAST 2), predicting the energy involved in mountain formation and erosion, calculating force, work, and energy, and using scientific notation. Graphing is used extensively as a tool to search for patterns and relationships. For example, students use graphs to find averages and compare with calculated means of densities of substances. Ratios also play an important role in FAST as in density, humidity, law of combining volumes, and gas laws. Angle measurements are employed in the study of light, azimuth and altitude calculations using astrolabes and sunscopes, and the formation and erosion of landforms. Students use a variety of formulae in calculating density, energy, work, mechanical equivalent of heat, calories in food, the specific heat of metals and liquids, universal laws of gravitation, and energy flow through ecosystems.
• Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.	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.

1. Science as Inquiry (Continued)

• Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances. • Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. • Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.	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 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. 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. FAST 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. 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.
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.
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.

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.	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.
• All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.	FAST Human Biology Supplement (optional) FAST 3, Change over Time—Unit 4, Life on Earth
• 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.	FAST Human Biology Supplement (optional)
• 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.	FAST Human Biology Supplement (optional)
• 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.	FAST Human Biology Supplement (optional)
• 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.	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.	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.
• 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.	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.	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.
• 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.	FAST 3, Change over Time—Unit 6, Changing Ecosystems.
• 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.	FAST 1, The Local Environment—E Unit 3, Animal Care FAST 3, Change over Time—Unit 6, Changing Ecosystems.
• 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.	FAST 3, Change over Time—Unit 6, Changing Ecosystems.
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.	FAST 1, The Local Environment—E Unit 4, Field Ecology FAST 3, Change over Time—Unit 6, Changing Ecosystems.
• 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.	FAST 1, The Local Environment—E Unit 4, Field Ecology; FAST 2, Matter & Energy in the Biosphere—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)

• 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.	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 6, Changing Ecosystems; Unit 7, Humans in the Environment. FAST 1, The Local Environment FAST 2, Mater & Energy in the Biosphere FAST 3, Change over Time.
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.	FAST 1, The Local Environment FAST 2, Matter & Energy in the Biosphere FAST 3, Change over Time
• 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.	FAST 3, Change over Time—Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems.
• 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.	FAST 3, Change over Time—Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems.

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.	These concepts are developed in investigations in: FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift

4. Earth and Space Science (Continued)

• 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.	FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift
• 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.	FAST 1, The Local Environment—E Unit 2, The Physical Environment FAST 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project
• 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.	FAST 1, The Local Environment—PS Unit 2, Change of State; E Unit 2, The Physical Environment; RS Unit 2, Water Resource Management
• Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans.	FAST 1, The Local Environment—PS Unit 2, Change of State; E Unit 2, The Physical Environment; RS Unit 2, Water Resource Management
• The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations.	FAST 1, The Local Environment—E Unit 2, The Physical Environment; RS Unit 1, Air Pollution
• Clouds, formed by the condensation of water vapor, affect weather and climate.	FAST 1, The Local Environment—PS Unit 2, Change of State; E Unit 2, The Physical Environment; RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management
• 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.	FAST 1, The Local Environment—E Unit 2, The Physical Environment; PS Unit 3, Temperature and Heat; FAST 2, Matter & Energy in the Biosphere—RS 2, World Food Production FAST 3, Change over Time—Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment
• 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.	FAST 3, Change over Time—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.	FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems
• Fossils provide important evidence of how life and environmental conditions have changed.	FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift

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.	FAST 3, Change over Time—Unit 3, The Changing Universe
• 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.	FAST 3, Change over Time—Unit 3, The Changing Universe
• 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.	FAST 3, Change over Time—Unit 1, Force, Work and Energy; Unit 2, The Changing Earth; Unit 3, The Changing Universe
• 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.	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 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)	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.	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—RS Unit 1, Productivity Project; RS Unit 2, World Food Production FAST 3, Change over Time—Unit 3, The Changing Universe; Unit 5, Continental Drift; Unit 7, Humans in the Environment
• Many different people in different cultures have made and continue to make contributions to science and technology.	FAST 2, Matter & Energy in the Biosphere—PS Unit 2, Evidence for an Atomic Theory 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
• 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.	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
• 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.	FAST 1, The Local Environment—RS Unit 1, Air Pollution; Unit 2, Water Resource Management FAST 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project FAST 3, Change over Time—Unit 3, The Changing Universe; Unit 5, Continental Drift; Unit 7, Humans in the Environment
• 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.	The Relational Study strand in all three FAST courses deals with these issues.
• Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.	FAST 3, Change over Time—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.	FAST Human Biology Supplement (optional)
• 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.	These issues are addressed in FAST through extensive emphasis on laboratory and field safety.
• 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.	FAST Human Biology Supplement (optional)
• Alcohol and other drugs are often abused substances. Such drugs change how the body functions and can lead to addiction.	FAST Human Biology Supplement (optional)
• Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.	FAST 2, Matter & Energy in the Biosphere—E Unit 1, Primary Production; E Unit 2, Respiration; E Unit 3. The Cycling of Matter
• 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.	FAST Human Biology Supplement (optional)
• 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.	FAST 1, The Local Environment—RS Unit 1, Air Pollution; RS Unit 2, Water Resource Management
Populations, resources, and environments	
• When an area becomes overpopulated, the environment will become degraded due to the increased use of resources.	FAST 3, Change over Time—Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment
• Causes of environmental degradation and resource depletion vary from region to region and from country to country.	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

6. Science in Personal and Social Perspectives (Continued)

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.	FAST 3, Change over Time—Unit 2, The Changing Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment
• Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes.	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 7, Humans in the Environment
• 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.
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).	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 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift; Unit 6, Changing Ecosystems; Unit 7, Humans in the Environment
• 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.	Systems analysis is introduced in FAST 2, Matter & Energy in the Biosphere and used throughout both FAST 2 and FAST 3. FAST 2, Matter & Energy in the Biosphere—RS Unit 1, Productivity Project
• Important personal and social decisions are made based on perceptions of benefits and risks.	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 7, Humans in the Environment

6. Science in Personal and Social Perspectives (Continued)

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.	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.
• Scientists and engineers have ethical codes requiring that human subjects involved with research be fully informed about risks and benefits associated with the research before the individuals choose to participate. This ethic extends to potential risks to communities and property. In short, prior knowledge and consent are required for research involving human subjects or potential damage to property. • Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.	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.

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.	FAST 2, Matter & Energy in the Biosphere—PS Unit 2, Evidence for an Atomic Theory FAST 3, Change over Time—Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift
• 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.	FAST is an integrated program involving students in investigations in the physical, biological, and earth sciences. 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.
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.	These concepts and issues are developed by students 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. FAST 3, Change over Time—Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift
• 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.	FAST 3, Change over Time—Unit 3, The Changing Universe; Unit 4, Life on Earth; Unit 5, Continental Drift
• 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.	FAST 1, The Local Environment FAST 2, Matter & Energy in the Biosphere FAST 3, Change over Time

7. History and Nature of Science (Continued)

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

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.
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.

8. Unifying Concepts and Processes (Continued)

Evidence, models, and explanations	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).
Change, constancy, and measurement	Measurement, computation, and estimation are integral parts of all three courses in 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. The CGS challenge game is used to help students improve their estimating skills. 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 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	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

The Curriculum Research & Development Group (CRDG), including the University Laboratory School, conducts systematic research, design, development, publication, staff development, and related services for elementary and secondary schools. The CRDG has curriculum development projects in science, mathematics, English, Pacific and Asian studies, marine studies, environmental studies, Hawaiian and Polynesian studies, Japanese language and culture, music, nutrition, art, drama, technology, health, and computer education. Research and school service projects focus on educational evaluation, teacher development, reduction of in-school segregation of students, and programs for students educationally at risk. The CRDG is the senior member of a cooperative program of ten universities in the United States to improve schooling in science, health, and technology in elementary and secondary schools. It is a founding member of the Pacific Circle Consortium of universities, major school systems, and educational ministries in Australia, Canada, Japan, New Zealand, and the United States. CRDG-developed programs are being used experimentally in other countries, including Australia, Israel, New Zealand, Russia, Indonesia, Singapore, and Slovakia. The CRDG provides professional development institutes and support services for all its projects. CRDG publishes and distributes its materials nationally and internationally.