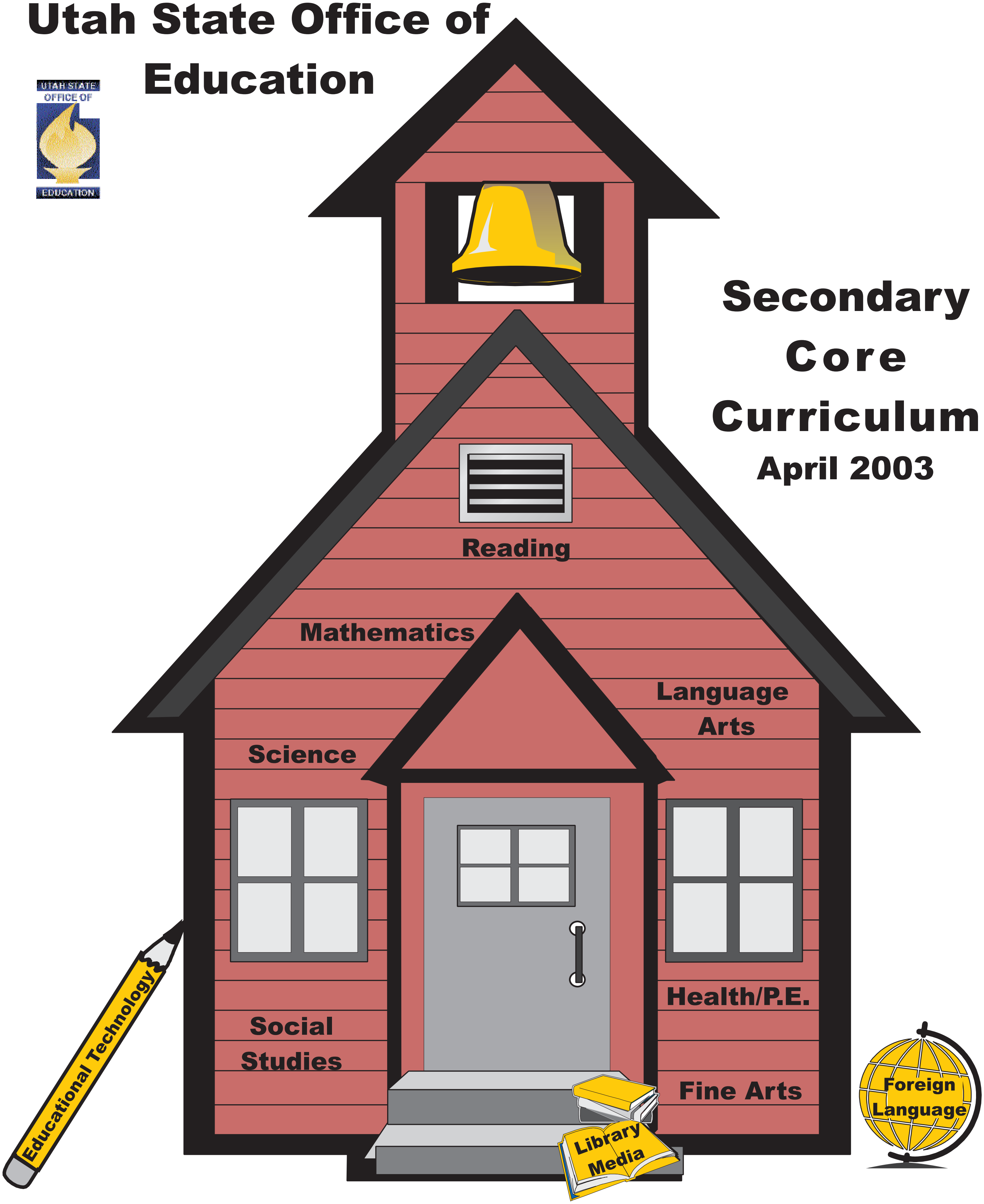
Utah State Office of Education



Secondary Core Curriculum

April 2003

Science - Earth Systems Science, Biology, Chemistry and Physics

SECONDARY CORE CURRICULUM

SCIENCE 9-12

EARTH SYSTEMS SCIENCE, BIOLOGY, CHEMISTRY AND PHYSICS

UTAH STATE OFFICE OF EDUCATION

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INTRODUCTION

Action by the Utah State Board of Education in January 1984 established a policy requiring the identification of specific Core Curriculum standards, which must be completed by all students K-12 as a requisite for graduation from Utah's secondary schools. This action was followed by three years of extensive work involving all levels of the education family in the process of identifying, trial testing, and refining these Core Curriculum standards for Utah's schools.

The Core Curriculum represents those standards of learning that are essential for all students. They are the ideas, concepts, and skills that provide a foundation on which subsequent learning may be built.

The Core should be taught with respect for differences in learning styles, learning rates, and individual capabilities without losing sight of the common goals. Although the Core Curriculum standards are intended to occupy a major part of the school program, they are not the total curriculum of a level or course.

R277. Education, Administration.

R277-700. The Elementary and Secondary School Core Curriculum.

R277-700-1. Definitions.

A. "Accredited" means evaluated and approved under the Standards for Accreditation of the Northwest Association of Schools and Colleges or the accreditation standards of the Board, available from the USOE Accreditation Specialist.

B. "Applied technology education (ATE)" means organized educational programs or courses which directly or indirectly prepare students for employment, or for additional preparation leading to employment, in occupations, where entry requirements generally do not require a baccalaureate or advanced degree.

C. "Basic skills course" means a subject which requires mastery of specific functions and was identified as a course to be assessed under Section 53A-1-602.

D. "Board" means the Utah State Board of Education.

E. "Core Curriculum content standard" means a broad statement of what students enrolled in public schools are expected to know and be able to do at specific grade levels or following completion of identified courses.

F. "Core Curriculum criterion-referenced test (CRTs)" means a test to measure performance against a specific standard. The meaning of the scores is not tied to the performance of other students.

G. "Core Curriculum objective" means a more focused description of what students enrolled in public schools are expected to know and do at the completion of instruction.

H. "Demonstrated competence" means subject mastery as determined by school district standards and review. School district review may include such methods and documentation as: tests, interviews, peer evaluations, writing samples, reports or portfolios.

I. "Elementary school" for purposes of this rule means grades K-6 in whatever kind of school the grade levels exist.

J. "High school" for purposes of this rule means grades 9-12 in whatever kind of school the grade levels exist.

K. "Individualized Education Program (IEP)" means a written statement for a student with a disability that is developed, reviewed, and revised in accordance with the Utah Special Education Rules and Part B of the Individuals with Disabilities Education Act (IDEA).

L. "Middle school" for purposes of this rule means grades 7-8 in whatever kind of school the grade levels exist.

M. "Norm-referenced test" means a test where the scores are based on comparisons with a nationally representative group of students in the same grade. The meaning of the scores is tied specifically to student performance relative to the performance of the students in the norm group under very specific testing conditions.

N. "State core Curriculum (Core Curriculum)" means those standards of learning that are essential for all Utah students, as well as the ideas, concepts, and skills that provide a foundation on which subsequent learning may be built, as established by the Board.

0. "USOE" means the Utah State Office of Education.

P. "Utah Basic Skills Competency Test" means a test to be administered to Utah students beginning in the tenth grade to include at a minimum components on English, language arts, reading and mathematics. Utah students shall satisfy the requirements of the Utah Basic Skills Competency Test in addition to school or district graduation requirements prior to receiving a basic high school diploma.

R277-700-2. Authority and Purpose.

A. This rule is authorized by Article X, Section 3 of the Utah Constitution, which places general control and supervision of the public schools under the Board; Section 53A-l-402(l)(b) and (c) which directs the Board to make rules regarding competency levels, graduation requirements, curriculum, and instruction requirements; Section 53A-1-402.6 which directs the Board to establish a Core Curriculum in consultation with local boards and superintendents and directs local boards to design local programs to help students master the Core Curriculum; and Section 53A-1-401(3) which allows the Board to adopt rules in accordance with its responsibilities.

B. The purpose of this rule is to specify the minimum Core Curriculum requirements for the public schools, to give directions to local boards and school districts about providing the Core Curriculum for the benefit of students, and to establish responsibility for mastery of Core Curriculum requirements.

R277-700-3. Core Curriculum Standards and Objectives.

A. The Board establishes minimum course description standards and objectives for each course in the required general core, which is commonly referred to as the Core Curriculum.

B. Course descriptions for required and elective courses shall be developed cooperatively by school districts and the USOE with opportunity for public and parental participation in the development process.

C. The descriptions shall contain mastery criteria for the courses, and shall stress mastery of the course material and Core objectives and standards rather than completion of predetermined time allotments for courses.

D. Implementation of the Core Curriculum and student assessment procedures are the responsibility of local boards of education consistent with state law.

E. This rule shall apply to students in the 2005-2006 graduating class.

R277-700-4. Elementary Education Requirements.

A. The Board shall establish a Core Curriculum for elementary schools, grades K-6.

B. Elementary School Education Core Curriculum Content Area Requirements:

(1) Grades K-2:
(a) Reading/Language Arts;
(b) Mathematics;
(c) Integrated Curriculum.
(2) Grades 3-6:
(a) Reading/Language Arts;
(b) Mathematics;
(c) Science;
(d) Social Studies;
(e) Arts:
(i) Visual Arts;
(ii) Music;
(iii) Dance;
(iv) Theatre.
(f) Health Education;
(g) Physical Education;
(h) Educational Technology;
(i) Library Media.

C. It is the responsibility of the local boards of education to provide access to the Core Curriculum to all students.

D. Student mastery of the general Core Curriculum is the responsibility of local boards of education.

E. Informal assessment should occur on a regular basis to ensure continual student progress.

F- Board-approved CRT's shall be used to assess student mastery of the following:

(1) reading;

(2) language arts;

(3) mathematics;

(4) science in elementary grades 4-6; and

(5) effectiveness of written expression.

G. Norm-referenced tests shall be given to all elementary students in grades 3 and 5.

H. Provision for remediation for all elementary students who do not achieve mastery is the responsibility of local boards of education.

R277-700-5. Middle School Education Requirements.

A. The Board shall establish a Core Curriculum for middle school education.

B. Students in grades 7-8 shall earn a minimum of 12 units of credit to be properly prepared for instruction in grades 9-12.

C. Local boards may require additional units of credit.

D. Grades 7-8 Core Curriculum Requirements and units of credit:

(1) General Core (10.5 units of credit):

(a) Language Arts (2.0 units of credit) ;

(b) Mathematics (2.0 units of credit);

(c) Science (1.5 units of credit);

(d) Social Studies (1.5 units of credit);

(e) The Arts (1.0 units of credit):

(i) Visual Arts;

(ii) Music;

(iii) Dance;

(iv) Theatre.

(f) Physical Education (1.0 units of credit);

(g) Health Education (0.5 units of credit);

(h) Applied Technology Education Technology, Life, and Careers (1.0 units of credit);

(i) Educational Technology (credit optional);

(j) Library Media (integrated into subject areas).

E. Board-approved CRT's shall be used to assess student mastery of the following:

(1) reading;

(2) language arts;

(3) mathematics;

(4) science in grades 7 and 8; and

(5) effectiveness of written expression.

F. Norm-referenced tests shall be given to all middle school students in grade 8.

R277-700-6. High School Requirements.

A. The Board shall establish a Core Curriculum for students in grades 9-12.

B. Students in grades 9-12 shall earn a minimum of 24 units of credit.

C. Local boards may require additional units of credit.

D. Grades 9-12 Core Curriculum requirements required units of credit:

(1) Language Arts (3.0 units of credit);

(2) Mathematics (2.0 units of credit):

(a) minimally, Elementary Algebra or Applied Mathematics I; and

(b) geometry or Applied Mathematics II; or

(c) any Advanced Mathematics courses in sequence beyond (a) and (b) ;

(d) high school mathematics credit may not be earned for courses in sequence below (a).

(3) Science (2.0 units of credit from two of the four science areas):

(a) earth science (1.0 units of credit);

(b) biological science (1.0 units of credit);

(c) chemistry (1.0 units of credit);

(d) physics (1.0 units of credit).

(4) Social Studies (3.0 units of credit):

(a) Geography for Life (0.5 units of credit);

(b) World Civilizations (0.5 units of credit);

(c) U.S. history (1.0 units of credit);

(d) U.S. Government and Citizenship (0.5 units of Credit);

(e) elective social studies class (0.5 units of

(5) The Arts (1.5 units of credit from any of the following performance areas):

(a) visual arts;

(b) music;

(c) dance;

(d) theatre;

(6) Health education (0.5 units of credit)

(7) Physical education (1.5 units of credit):

(a) participation skills (0.5 units of credit);

(b) Fitness for Life (0.5 units of credit);

(c) individualized lifetime activities (0.5 units of credit) or team sport/athletic participation (maximum of 0.5 units of credit with school approval).

(8) Applied technology education (1.0 units of credit);

(a) agriculture;

(b) business;

(c) family and consumer sciences;

(d) technology education;

(h) trade and technical education.

(9) Educational technology:

(a) computer Technology (0.5 units of credit for the class by this specific name only); or

(b) successful completion of state-approved competency examination (no credit, but satisfies the Core requirement).

(10) Library media skills integrated into the curriculum;

(11) Board-approved CRT's shall be used to assess student mastery of the following subjects:

(a) reading;

(b) language arts through grade 11;

(c) mathematics as defined under R277-700-6D(2);

(d) science as defined under R277-700-6D(3); and

(e) effectiveness of written expression.

E. Students shall participate in the Utah Basic Skills Competency Test, as defined under R277-700-1O.

F. Students with disabilities served by special education programs may have changes made to graduation requirements through individual IEPs to meet unique educational needs. A student's IEP shall document the nature and extent of modifications, substitutions or exemptions made to accommodate a student with disabilities.

R277-700.7. Student Mastery and Assessment of Core Curriculum Standards and Objectives.

A. Student mastery of the Core Curriculum at all levels is the responsibility of local boards of education.

B. Provisions for remediation of secondary students who do not achieve mastery is the responsibility of local boards of education under Section 53A-13-104.

C. Students who are found to be deficient in basic skills through U-PASS shall receive remedial assistance according to provisions of Section 53A-1-606(1).

D. If parents object to portions of courses or courses in their entirety under provisions of law (Section 53A-13-101.2) and rule (R277-105), students and parents shall be responsible for the mastery of Core objectives to the satisfaction of the school prior to promotion to the next course or grade level.

E. Students with Disabilities:

(1) All students with disabilities served by special education programs shall demonstrate mastery of the Core Curriculum.

(2) If a student's disabling condition precludes the successful demonstration of mastery, the student's IEP team, on a case-by-case basis, may provide accommodations for or modify the mastery demonstration to accommodate the student's disability.

F. Students may demonstrate competency to satisfy course requirements consistent with R277-705-3.

G. All Utah public school students shall participate in state-mandated assessments, as required by law.

KEY: curricula
March 5, 2002

Art X Sec 3
53A-1-402(1)(b
53A-1-402.6
53A-1-401(3

Utah Secondary Science Core Curriculum

Science instruction should cultivate and build on students' curiosity and sense of wonder.

Earth Systems Science, Biology, Chemistry and Physics Science

Utah Science Core Curriculum
Earth Systems Science, Biology, Physics and Chemistry

Introduction

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. The Science Core Curriculum places emphasis on understanding and using skills. Students should be active learners. It is not enough for students to read about science; they must do science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands-on, active experiences throughout the instruction of the science curriculum.

The Science Core describes what students should know and be able to do at the end of each course. It was developed, critiqued, piloted, and revised by a community of Utah science teachers, university science educators, State Office of Education specialists, scientists, expert national consultants, and an advisory committee representing a wide diversity of people from the community. The Core reflects the current philosophy of science education that is expressed in national documents developed by the American Association for the Advancement of Science and the National Academies of Science. This Science Core has the endorsement of the Utah Science Teachers Association. The Core reflects high standards of achievement in science for all students.

Organization of the Science Core

The Core is designed to help teachers organize and deliver instruction. Elements of the Core include the following:

- ✓ Each grade level begins with a brief course description.
- ✓ The INTENDED LEARNING OUTCOMES (ILOs) describe the goals for science skills and attitudes. They are found at the beginning of each grade, and are an integral part of the Core that should be included as part of instruction.
- ✓ The SCIENCE BENCHMARKS describe the science content students should know. Each grade level has three to five Science Benchmarks. The ILOs and Benchmarks intersect in the Standards, Objectives and Indicators.
- ✓ A STANDARD is a broad statement of what students are expected to understand. Several Objectives are listed under each Standard.
- ✓ An OBJECTIVE is a more focused description of what students need to know and be able to do at the completion of instruction. If students have mastered the Objectives associated with a given Standard, they are judged to have mastered that Standard at that grade level. Several Indicators are described for each Objective.
- ✓ An INDICATOR is a measurable or observable student action that enables one to judge whether a student has mastered a particular Objective. Indicators are not meant to be classroom activities, but they can help guide classroom instruction.
- ✓ SCIENCE LANGUAGE STUDENTS SHOULD USE is a list of terms that students and teachers should integrate into their normal daily conversations around science topics. These are **not** vocabulary lists for students to memorize.

Seven Guidelines Used in Developing the Science Core

Reflects the Nature of Science: Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. The Core is designed to produce an integrated set of Intended Learning Outcomes (ILOs) for students.

As described in these ILOs, students will:

- Use science process and thinking skills.
- Manifest science interests and attitudes.
- Understand important science concepts and principles.
- Communicate effectively using science language and reasoning.
- Demonstrate awareness of the social and historical aspects of science.
- Understand the nature of science.

Coherent: The Core has been designed so that, wherever possible, the science ideas taught within a particular grade level have a logical and natural connection with each other and with those of earlier grades. Efforts have also been made to select topics and skills that integrate well with one another and with other subject areas appropriate to grade level. In addition, there is an upward articulation of science concepts, skills, and content. This spiraling is intended to prepare students to understand and use more complex science concepts and skills as they advance through their science learning.

Developmentally Appropriate: The Core takes into account the psychological and social readiness of students. It builds from concrete experiences to more abstract understandings. The Core describes science language students should use that is appropriate to their grade level. A more extensive vocabulary should not be emphasized. In the past, many educators may have mistakenly thought that students understood abstract concepts (such as the nature of the atom) because they repeated appropriate names and vocabulary (such as "electron" and "neutron"). The Core resists the temptation to describe abstract concepts at inappropriate grade levels; rather, it focuses on providing experiences with concepts that students can explore and understand in depth to build a foundation for future science learning.

Encourages Good Teaching Practices: It is impossible to accomplish the full intent of the Core by lecturing and having students read from textbooks. The Science Core emphasizes student inquiry. Science process skills are central in each standard. Good science encourages students to gain knowledge by doing science: observing, questioning, exploring, making and testing hypotheses, comparing predictions, evaluating data, and communicating conclusions. The Core is designed to encourage instruction with students working in cooperative groups. Instruction should connect lessons with students' daily lives. The Core directs experiential science instruction for all students, not just those who have traditionally succeeded in science classes. The vignettes listed on the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science for each of the Core standards provide examples, based on actual practice, that demonstrate that excellent teaching of the Science Core is possible.

Comprehensive: The Science Core does not cover all topics that have traditionally been in the science curriculum; however, it does provide a comprehensive background in science. By emphasizing depth rather than breadth, the Core seeks to empower students rather than intimidate them with a collection of isolated and forgettable facts. Teachers are free to add related concepts and skills, but they are expected to teach all the standards and objectives specified in the Core for their grade level.

Useful and Relevant: This curriculum relates directly to student needs and interests. It is grounded in the natural world in which we live. Relevance of science to other endeavors enables students to transfer skills gained from science instruction into their other school subjects and into their lives outside the classroom.

Encourages Good Assessment Practices: Student achievement of the standards and objectives in this Core is best assessed using a variety of assessment instruments. The purpose of an assessment should be clear to the teacher as it is planned, implemented, and evaluated. Performance tests are particularly appropriate to evaluate student mastery of science processes and problem-solving skills. Teachers should use a variety of classroom assessment approaches in conjunction with standard assessment instruments to inform their instruction. Sample test items, keyed to each Core Standard, may be located on the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science. Observation of students engaged in science activities is highly recommended as a way to assess students' skills as well as attitudes in science. The nature of the questions posed by students provides important evidence of students' understanding of and interest in science.

Intended Learning Outcomes for Earth Systems Science, Biology, Chemistry and Physics

The Intended Learning Outcomes (ILOs) describe the skills and attitudes students should learn as a result of science instruction. They are an essential part of the Science Core Curriculum and provide teachers with a standard for evaluation of student learning in science. Instruction should include significant science experiences that lead to student understanding using the ILOs.

The main intent of science instruction in Utah is that students will value and use science as a process of obtaining knowledge based upon observable evidence.

By the end of science instruction in high school, students will be able to:

1. Use Science Process and Thinking Skills

a. Observe objects, events and patterns and record both qualitative and quantitative information.
b. Use comparisons to help understand observations and phenomena.
c. Evaluate, sort, and sequence data according to given criteria.
d. Select and use appropriate technological instruments to collect and analyze data.
e. Plan and conduct experiments in which students may:
   - Identify a problem.
   - Formulate research questions and hypotheses.
   - Predict results of investigations based upon prior data.
   - Identify variables and describe the relationships between them.
   - Plan procedures to control independent variables.
   - Collect data on the dependent variable(s).
   - Select the appropriate format (e.g., graph, chart, diagram) and use it to summarize the data obtained.
   - Analyze data, check it for accuracy and construct reasonable conclusions.
   - Prepare written and oral reports of investigations.

f. Distinguish between factual statements and inferences.
g. Develop and use classification systems.
h. Construct models, simulations and metaphors to describe and explain natural phenomena.
i. Use mathematics as a precise method for showing relationships.
j. Form alternative hypotheses to explain a problem.

2. Manifest Scientific Attitudes and Interests

a. Voluntarily read and study books and other materials about science.
b. Raise questions about objects, events and processes that can be answered through scientific investigation.
c. Maintain an open and questioning mind toward ideas and alternative points of view.
d. Accept responsibility for actively helping to resolve social, ethical and ecological problems related to science and technology.
e. Evaluate scientifically related claims against available evidence.
f. Reject pseudoscience as a source of scientific knowledge.

3. Demonstrate Understanding of Science Concepts, Principles and Systems

a. Know and explain science information specified for the subject being studied.
b. Distinguish between examples and non-examples of concepts that have been taught.
c. Apply principles and concepts of science to explain various phenomena.
d. Solve problems by applying science principles and procedures.

4. Communicate Effectively Using Science Language and Reasoning

a. Provide relevant data to support their inferences and conclusions.
b. Use precise scientific language in oral and written communication.
c. Use proper English in oral and written reports.
d. Use reference sources to obtain information and cite the sources.
e. Use mathematical language and reasoning to communicate information.

5. Demonstrate Awareness of Social and Historical Aspects of Science

a. Cite examples of how science affects human life.
b. Give instances of how technological advances have influenced the progress of science and how science has influenced advances in technology.
c. Understand the cumulative nature of scientific knowledge.
d. Recognize contributions to science knowledge that have been made by both women and men.

6. Demonstrate Understanding of the Nature of Science

a. Science is a way of knowing that is used by many people, not just scientists.
b. Understand that science investigations use a variety of methods and do not always use the same set of procedures; understand that there is not just one "scientific method."
c. Science findings are based upon evidence.
d. Understand that science conclusions are tentative and therefore never final. Understandings based upon these conclusions are subject to revision in light of new evidence.
e. Understand that scientific conclusions are based on the assumption that natural laws operate today as they did in the past and that they will continue to do so in the future.
f. Understand the use of the term "theory" in science, and that the scientific community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.
g. Understand that various disciplines of science are interrelated and share common rules of evidence to explain phenomena in the natural world.
h. Understand that scientific inquiry is characterized by a common set of values that include logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results and honest and ethical reporting of findings. These values function as criteria in distinguishing between science and non-science.
i. Understand that science and technology may raise ethical issues for which science, by itself, does not provide solutions.

Science language students should use:	generalize, conclude, hypothesis, theory, variable, measure, evidence, data, inference, infer, compare, predict, interpret, analyze, relate, calculate, observe, describe, classify, technology, experiment, investigation, tentative, assumption, ethical, replicability, precision, skeptical, methods of science

Earth Systems Science Core Curriculum

Life and physical science content are integrated in a curriculum with two primary goals: (1) students will value and use science as a process of obtaining knowledge based on observable evidence, and (2) students' curiosity will be sustained as they develop the abilities associated with scientific inquiry. This course builds upon students' experience with integrated science in grades seven and eight and is the springboard course for success in biology, chemistry, geology, and physics.

Theme

The theme for Earth Systems Science is **systems.** The "Benchmarks" in the Earth Systems Science Core emphasize "systems" as an organizing concept to understand life on Earth, geological change, and the interaction of atmosphere, hydrosphere, and biosphere. Earth Systems Science provides students with an understanding of how the parts of a system interact. The concept of matter cycling and energy flowing is used to help understand how systems on planet Earth are interrelated.

Inquiry

Throughout this course students experience science as a way of knowing based on making observations, gathering data, designing experiments, making inferences, drawing conclusions, and communicating results. Students see that the science concepts apply to their lives and their society. This course will provide students with science skills to make informed and responsible decisions. Students will learn how to explain cosmic and global phenomena in terms of interactions of energy, matter, and life. These explorations range from the realization that all elements heavier than helium were made in stars to an understanding of how rain influences a desert ecosystem.

Good science instruction requires hands-on science investigations in which student inquiry is an important goal. Teachers should provide opportunities for **all** students to experience many things. Students in Earth Systems Science should design and perform experiments and value inquiry as the fundamental scientific process. They should be encouraged to maintain an open and questioning mind to pose their own questions about objects, events, processes, and results. They should have the opportunity to plan and conduct their own experiments, and come to their own conclusions as they read, observe, compare, describe, infer, and draw conclusions. The results of their experiments need to be compared for reasonableness to multiple sources of information. It is important for students at this age to begin to formalize the processes of science and be able to identify the variables in an experiment.

Relevant

Earth Systems Science Core concepts should be integrated with concepts and skills from other curriculum areas. Reading, writing, and mathematics skills should be emphasized as integral to the instruction of science. Personal relevance of science in students' lives is an important part of helping students to value science and should be emphasized at this grade level. Developing students' writing skills in science should be an important part of science instruction in the ninth grade. Students should regularly write descriptions of their observations and experiments. Lab journals are an effective way to emphasize the importance of writing in science.

Providing opportunities for students to gain insights into science related careers adds to the relevance of science learning. The topics in Earth Systems Science introduce students to fundamental concepts related to careers in geology, hydrology, meteorology, and ecology. This is an excellent opportunity for students to broaden their understanding of careers in these areas. Resources related to careers in science may be found at the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science .

Character
Value for honesty, integrity, self-discipline, respect, responsibility, punctuality, dependability, courtesy, cooperation, consideration, and teamwork should be emphasized as an integral part of science learning. These relate to the care of living things, safety and concern for self and others, and environmental stewardship. Honesty in all aspects of research, experimentation, data collection, and reporting is an essential component of science.

Resources for Instruction
This Core was designed using the American Association for the Advancement of Science's *Project 2061: Benchmarks for Science Literacy* and the National Academy of Science's *National Science Education Standards* as guides to determine appropriate content and skills.

The Earth Systems Science Core has three online resources designed to help with classroom instruction. These resources include the *Sci-ber Text,* an electronic science textbook; web resources listed by Core objective; and the science test item pool. This pool includes multiple-choice questions, performance tasks, and interpretive items aligned to the standards and objectives of the Core. These resources are all aligned to the Core and available on the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science.

Safety Precautions
The hands-on nature of science learning increases the need for teachers to use appropriate precautions in the classroom and field. Proper handling and disposal of chemicals is crucial for a safe classroom.

Appropriate Use of Living Things in the Science Classroom
It is important to maintain a safe, humane environment for animals in the classroom. Field activities should be well thought out and use appropriate and safe practices. Student collections should be done under the guidance of the teacher with attention to the impact on the environment. The number and size of the samples taken for the collections should be considered in light of the educational benefit. Some organisms should not be taken from the environment, but rather observed and described using photographs, drawings, or written descriptions to be included in the student's collection. Teachers must adhere to the published guidelines for the proper use of animals, equipment, and chemicals in the classroom. These guidelines are available on the Utah Science Home Page.

The Most Important Goal
Science instruction should cultivate and build on students' curiosity and sense of wonder. Effective science instruction engages students in enjoyable learning experiences. Science instruction should be as thrilling an experience for a student as opening a rock and seeing a fossil, determining the quality of a water sample by watching the colors change in a chemical reaction, or observing the consistent sequence of color in a rainbow. Science is not just for those who have traditionally succeeded in the subject, and it is not just for those who will choose science-related careers. In a world of rapidly expanding knowledge and technology, all students must gain the skills they will need to understand and function responsibly and successfully in the world. The Core encourages instruction that provides skills in a context that enables students to experience the joy of doing science.

Earth Systems Science Core Curriculum

Science Benchmark

Science provides evidence that the universe is more than 10 billion years old. The most accepted science theory states that the universe expanded explosively from a hot, dense chaotic mass. Gravity causes clouds of the lightest elements to condense into massive bodies. The mass and density of these bodies may become great enough for nuclear fusion to occur, creating stars. Nuclear fusion releases energy and fuses light elements into heavier elements. Some stars explode, producing clouds of heavy elements from which other stars, planets, and celestial bodies may form.

Standard 1: Students will understand the scientific evidence that supports theories that explain how the universe and solar system developed.

Objective 1: Describe the big bang theory and evidence supporting it.

a. Determine the motion of a star relative to Earth based on a red or blue shift in the wavelength of light from the star.
b. Explain how evidence of red and blue shifts is used to determine whether the universe is expanding or contracting.
c. Describe the big bang theory and the red shift evidence that supports this theory.
d. Investigate and report how science has changed the accepted ideas regarding the nature of the universe throughout history.
e. Provide an example of how technology has helped scientists investigate the universe.

Objective 2: Relate the structure and composition of the solar system to the processes that exist in the universe.

a. Compare the elements formed in the big bang (hydrogen, helium) with elements formed through nuclear fusion in stars.
b. Relate the life cycle of stars of various masses to the relative mass of elements produced.
c. Explain the origin of the heavy elements on Earth (i.e., heavy elements were formed by fusion in ancient stars).
d. Present evidence that the process that formed Earth's heavy elements continues in stars today.
e. Compare the life cycle of the sun to the life cycle of other stars.
f. Relate the structure of the solar system to the forces acting upon it.

Science language students should use:	big bang theory, blue shift, heavy element, mass, nuclear fusion, red shift, theory, universe, astronomy

Science Benchmark

Earth supports an interconnected system of living organisms. This system is unique in the solar system. Biodiversity on Earth is determined by biotic and abiotic factors. Throughout Earth's history, the number and distribution of species have changed over time in response to environmental changes.

Standard 2: Students will understand that the features of Earth's evolving environment affect living systems, and that life on Earth is unique in the solar system.

Objective 1: Describe the unique physical features of Earth's environment that make life on Earth possible.

a. Compare Earth's atmosphere, solar energy, and water to those of other planets and moons in the solar system.
b. Compare the conditions that currently support life on Earth to the conditions that exist on other planets in the solar system.
c. Evaluate evidence for existence of life in other star systems, planets, or moons, either now or in the past.

Objective 2: Analyze how ecosystems differ from each other due to abiotic and biotic factors.

a. Observe and list abiotic factors (e.g., temperature, water, nutrients, sunlight, pH, topography) in specific ecosystems.
b. Observe and list biotic factors (e.g., plants, animals, organic matter) that affect a specific ecosystem (e.g., wetlands, deserts, aquatic).
c. Predict how an ecosystem will change as a result of major changes in an abiotic and/or biotic factor.
d. Explain that energy enters the vast majority of Earth's ecosystems through photosynthesis, and compare the path of energy through two different ecosystems.
e. Analyze interactions within an ecosystem (e.g., water temperature and fish species, weathering and water pH).
f. Plan and conduct an experiment to investigate how abiotic factors influence organisms and how organisms influence the physical environment.

Objective 3: Examine Earth's diversity of life as it changes over time.

a. Observe and chart the diversity in a specific area.
b. Compare the diversity of life in various biomes specific to number of species, biomass, and type of organisms.
c. Explain factors that contribute to the extinction of a species.
d. Compare evidence supporting various theories that explain the causes of large-scale extinctions in the past with factors causing the loss of species today.
e. Evaluate the biological, esthetic, ethical, social, or economic arguments with regard to maintaining biodiversity.

Science language students should use:	abiotic, atmosphere, biodiversity, biome, biotic, ecosystem, extinction, system, aesthetic, ethical, social, economic, stellar, photosynthesis, biomass, species

Science Benchmark

The theory of plate tectonics explains the features of Earth's surface, earthquakes and volcanoes. Plates move very slowly, pressing against one another, sliding past one another, and pulling apart. The internal energy of the Earth drives the movement of the plates. The slow movement of materials within Earth results from heat flowing out from the deep interior and the action of gravity on regions of different density. Evidence for plate tectonics includes the spreading of the seafloor, the fossil record, and patterns and distribution of earthquakes and volcanoes. Processes in Earth affect the atmosphere, biosphere, and hydrosphere. Processes occurring in these spheres affect the geosphere.

Standard 3: Students will understand that gravity, density, and convection move Earth's plates and this movement causes the plates to impact other Earth systems.

Objective 1: Explain the evidence that supports the theory of plate tectonics.

a. Define and describe the location of the major plates and plate boundaries.
b. Compare the movement and results of movement along convergent, divergent, and transform plate boundaries.
c. Relate the location of earthquakes and volcanoes to plate boundaries.
d. Explain Alfred Wegener's continental drift hypothesis, his evidence, and why it was not accepted in his time.
e. Evaluate the evidence for the current theory of plate tectonics.

Objective 2: Describe the processes within Earth that result in plate motion and relate it to changes in other Earth systems.

a. Identify the energy sources that cause material to move within Earth.
b. Model the movement of materials within Earth.
c. Model the movement and interaction of plates.
d. Relate the movement and interaction of plates to volcanic eruptions, mountain building, and climate changes.
e. Predict the effects of plate movement on other Earth systems (e.g., volcanic eruptions affect weather, mountain building diverts waterways, uplift changes elevation that alters plant and animal diversity, upwelling from ocean vents results in changes in biomass).

Science language students should use:	plate tectonics, convergent, divergent, transform, plate, convection current, hypothesis, theory, seafloor spreading, biomes, climate, weather, geosphere, biosphere, hydrosphere, volcanic eruption, hot spot, fault

Science Benchmark

Water moves through different holding places in the hydrosphere, with the ocean being the largest reservoir for water. The energy from the sun moves water from one reservoir to another, resulting in the water cycle. Freshwater, though limited in supply, is essential for life. Freshwater may become depleted or polluted.

Standard 4: Students will understand that water cycles through and between reservoirs in the hydrosphere and affects the other spheres of the Earth system.

Objective 1: Explain the water cycle in terms of its reservoirs, the movement between reservoirs, and the energy to move water. Evaluate the importance of freshwater to the biosphere.

a. Identify the reservoirs of Earth's water cycle (e.g., ocean, ice caps/glaciers, atmosphere, lakes, rivers, biosphere, groundwater) locally and globally, and graph or chart relative amounts in global reservoirs.
b. Illustrate the movement of water on Earth and describe how the processes that move water (e.g., evaporation of water, melting of ice/snow, ocean currents, movement of water vapor by wind) use energy from the sun.
c. Relate the physical and chemical properties of water to a water pollution issue.
d. Make inferences about the quality and/or quantity of freshwater, using data collected from local water systems.
e. Analyze how communities deal with water shortages, distribution, and quality in designing a long-term water use plan.

Objective 2: Analyze the physical and biological dynamics of the oceans.

a. Describe the physical dynamics of the oceans (e.g., wave action, ocean currents, El Nino, tides).
b. Determine how physical properties of oceans affect organisms (e.g., salinity, depth, tides, temperature).
c. Model energy flow in ocean ecosystems.
d. Research and report on changing ocean levels over geologic time, and relate changes in ocean level to changes in the water cycle.
e. Describe how changing sea levels could affect life on Earth.

Science language students should use:	groundwater, reservoir, salinity, glacier, biological dynamics, tide, geologic time

Science Benchmark

Earth's atmosphere interacts with and is changed by the lithosphere, hydrosphere, and biosphere. The atmosphere changes rapidly compared to the other spheres. Atmospheric changes affect climate and life over short and long periods of time.

Standard 5: Students will understand that Earth's atmosphere interacts with and is altered by the lithosphere, hydrosphere, and biosphere.

Objective 1: Describe how matter in the atmosphere cycles through other Earth systems.

a. Trace movement of a carbon atom from the atmosphere through a plant, animal, and decomposer, and back into the atmosphere.
b. Diagram the nitrogen cycle and provide examples of human actions that affect this cycle (e.g., fertilizers, crop rotation, fossil fuel combustion).
c. Interpret evidence suggesting that humans are influencing the carbon cycle.
d. Research ways the biosphere, hydrosphere, and lithosphere interact with the atmosphere (e.g., volcanic eruptions putting ash and gases into the atmosphere, hurricanes, changes in vegetation).

Objective 2: Trace ways in which the atmosphere has been altered by living systems and has itself strongly affected living systems over the course of Earth's history.

a. Define ozone and compare its effects in the lower and upper atmosphere.
b. Describe the role of living organisms in producing the ozone layer and how the ozone layer affected the development of life on Earth.
c. Compare the rate at which CO_2 is put into the atmosphere to the rate at which it is removed through the carbon cycle.
d. Analyze data relating to the concentration of atmospheric CO_2 over the past 100 years.
e. Research, evaluate, and report on international efforts to protect the atmosphere.

Science language students should use:	carbon cycle, climate, decomposer, matter, nitrogen cycle, ozone layer, depletion, fossil fuel, lithosphere

Science Benchmark

The sun is the major source of Earth's energy. Some of the solar radiation that reaches Earth is reflected, but most is absorbed. Gases in the atmosphere trap some of the heat energy and delay its radiation into space. This greenhouse effect retains energy longer in the Earth system. Currents in the atmosphere and hydrosphere distribute solar heat energy. These currents help determine global and local weather and climate patterns. Photosynthesis uses a small but vital part of the total solar energy for the biosphere. This energy is stored in the chemical bonds of sugars formed in plants.

Standard 6: Students will understand the source and distribution of energy on Earth and its effects on Earth systems.

Objective 1: Describe the transformation of solar energy into heat and chemical energy on Earth and eventually the radiation of energy to space.

a. Illustrate the distribution of energy coming from the sun that is reflected, changed into heat, or stored by plants.
b. Describe the pathways for converting and storing light energy as chemical energy (e.g., light energy converted to chemical energy stored in plants, plants become fossil fuel).
c. Investigate the conversion of light energy from the sun into heat energy by various Earth materials.
d. Demonstrate how absorbed solar energy eventually leaves the Earth system as heat radiating to space.
e. Construct a model that demonstrates the reduction of heat loss due to a greenhouse effect.
f. Research global changes and relate them to Earth systems (e.g., global warming, solar fluctuations).

Objective 2: Relate energy sources and transformation to the effects on Earth systems.

a. Describe the difference between climate and weather, and how technology is used to monitor changes in each.
b. Describe the effect of solar energy on the determination of climate and weather (e.g., El Nino, solar intensity).
c. Explain how uneven heating at the equator and polar regions creates atmospheric and oceanic convection currents that move heat energy around Earth.
d. Describe the Coriolis effect and its role in global wind and ocean current patterns.
e. Relate how weather patterns are the result of interactions among ocean currents, air currents, and topography.

Science language students should use:	absorbed, Coriolis effect, energy, greenhouse gas, meteorology, radiation, reflected, topography

Biology Core Curriculum

The Biology Core Curriculum has two primary goals: (1) students will value and use science as a process of obtaining knowledge based on observable evidence, and (2) students' curiosity will be sustained as they develop and refine the abilities associated with scientific inquiry.

Theme

The Biology Core has three major concepts for the focus of instruction: (1) the structures in all living things occur as a result of necessary functions. (2) Interactions of organisms in an environment are determined by the biotic and abiotic components of the environment. (3) Evolution of species occurs over time and is related to the environment in which the species live.

Inquiry

Biology students should design and perform experiments, and value inquiry as the fundamental scientific process. They should be encouraged to maintain an open and questioning mind, to pose their own questions about objects, events, processes, and results. They should have the opportunity to plan and conduct their own experiments, and come to their own conclusions as they read, observe, compare, describe, infer, and draw conclusions. The results of their experiments need to be compared for reasonableness to multiple sources of information. They should be encouraged to use reasoning as they apply biology concepts to their lives.

Good science instruction requires hands-on science investigations in which student inquiry is an important goal. Teachers should provide opportunities for **all** students to experience many things. Students should investigate living organisms from each kingdom. Laboratory investigations should be frequent and meaningful components of biology instruction. Students should enjoy science as a process of discovering and understanding the natural world.

Relevance

Biology Core concepts should be integrated with concepts and skills from other curriculum areas. Reading, writing, and mathematics skills should be emphasized as integral to the instruction of science. Personal relevance of science in students' lives is an important part of helping students to value science and should be emphasized at this grade level. Developing students' writing skills in science should be an important part of science instruction in biology. Students should regularly write descriptions of their observations and experiments. Lab journals are an effective way to emphasize the importance of writing in science.

Providing opportunities for students to gain insights into science related careers adds to the relevance of science learning. Biology provides students with an opportunity to investigate careers in genetics, biotechnology, wildlife management, environmental science, and many fields of medicine. Resources related to careers in science may be found at the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science .

Character

Value for honesty, integrity, self-discipline, respect, responsibility, punctuality, dependability, courtesy, cooperation, consideration, and teamwork should be emphasized as an integral part of science learning. These relate to the care of living things, safety and concern for self and others, and environmental stewardship. Honesty in all aspects of research, experimentation, data collection, and reporting is an essential component of science.

Instructional Resources
This Core was designed using the American Association for the Advancement of Science's *Project 2061: Benchmarks for Science Literacy* and the National Academy of Science's *National Science Education Standards* as guides to determine appropriate content and skills.

The Biology Core has many online resources designed to help with classroom instruction. The Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science is an ongoing report of resources available and aligned to the Biology Core Curriculum.

Safety Precautions
The hands-on nature of science learning increases the need for teachers to use appropriate precautions in the classroom and field. Proper handling and disposal of chemicals is crucial for a safe classroom. The chemistry described in biology can be accomplished using safe household chemicals and microchemistry techniques. It is important that all students understand the rules for a safe classroom.

Appropriate Use of Living Things in the Science Classroom
It is important to maintain a safe, humane environment for animals in the classroom. Field activities should be well thought out and use appropriate and safe practices. Student collections should be done under the guidance of the teacher with attention to the impact on the environment. The number and size of the samples taken for the collections should be considered in light of the educational benefit. Some organisms should not be taken from the environment, but rather observed and described using photographs, drawings, or written descriptions to be included in the student's collection. Teachers must adhere to the published guidelines for the proper use of animals, equipment, and chemicals in the classroom. These guidelines are available on the Utah Science Home Page.

The Most Important Goal
Science instruction should cultivate and build on students' curiosity and sense of wonder. Effective science instruction engages students in enjoyable learning experiences. Science instruction should be as thrilling an experience for a student as opening a rock and seeing a fossil, tracing and interpreting a pedigree, or observing the affects of some chemical on the heartbeat of daphnia. Science is not just for those who have traditionally succeeded in the subject, and it is not just for those who will choose science-related careers. In a world of rapidly expanding knowledge and technology, all students must gain the skills they will need to understand and function responsibly and successfully in the world. The Core provides skills in a context that enables students to experience the joy of doing science.

Biology Core Curriculum

Science Benchmark

Ecosystems are shaped by interactions among living organisms and their physical environment. Ecosystems change constantly, either staying in a state of dynamic balance or shifting to a new state of balance. Matter cycles in ecosystems, and energy flows from outside sources through the system. Humans are part of ecosystems and can deliberately or inadvertently alter an ecosystem.

Standard 1: Students will understand that living organisms interact with one another and their environment.

Objective 1: Summarize how energy flows through an ecosystem.

a. Arrange components of a food chain according to energy flow.
b. Compare the quantity of energy in the steps of an energy pyramid.
c. Describe strategies used by organisms to balance the energy expended to obtain food to the energy gained from the food (e.g., migration to areas of seasonal abundance, switching type of prey based upon availability, hibernation or dormancy).
d. Compare the relative energy output expended by an organism in obtaining food to the energy gained from the food (e.g., hummingbird - energy expended hovering at a flower compared to the amount of energy gained from the nectar, coyote - chasing mice to the energy gained from catching one, energy expended in migration of birds to a location with seasonal abundance compared to energy gained by staying in a cold climate with limited food).
e. Research food production in various parts of the world (e.g., industrialized societies' greater use of fossil fuel in food production, human health related to food product).

Objective 2: Explain relationships between matter cycles and organisms.

a. Use diagrams to trace the movement of matter through a cycle (i.e., carbon, oxygen, nitrogen, water) in a variety of biological communities and ecosystems.
b. Explain how water is a limiting factor in various ecosystems.
c. Distinguish between inference and evidence in a newspaper, magazine, journal, or Internet article that addresses an issue related to human impact on cycles of matter in an ecosystem and determine the bias in the article.
d. Evaluate the impact of personal choices in relation to the cycling of matter within an ecosystem (e.g., impact of automobiles on the carbon cycle, impact on landfills of processed and packaged foods).

Objective 3: Describe how interactions among organisms and their environment help shape ecosystems.

a. Categorize relationships among living things according to predator-prey, competition, and symbiosis.
b. Formulate and test a hypothesis specific to the effect of changing one variable upon another in a small ecosystem.
c. Use data to interpret interactions among biotic and abiotic factors (e.g., pH, temperature, precipitation, populations, diversity) within an ecosystem.
d. Investigate an ecosystem using methods of science to gather quantitative and qualitative data that describe the ecosystem in detail.
e. Research and evaluate local and global practices that affect ecosystems.

Science language students should use:	predator-prey, symbiosis, competition, ecosystem, carbon cycle, nitrogen cycle, oxygen cycle, population, diversity, energy pyramid, consumers, producers, limiting factor, competition, decomposers, food chain, biotic, abiotic, community, variable, evidence, inference, quantitative, qualitative

Science Benchmark

Cells are the basic unit of life. All living things are composed of one or more cells that come from preexisting cells. Cells perform a variety of functions necessary to maintain homeostasis and life. The structure and function of a cell determines the cell's role in an organism. Living cells are composed of chemical elements and molecules that form large, complex molecules. These molecules form the basis for the structure and function of cells.

Standard 2: Students will understand that all organisms are composed of one or more cells that are made of molecules, come from preexisting cells, and perform life functions.

Objective 1: Describe the fundamental chemistry of living cells.

a. List the major chemical elements in cells (i.e., carbon, hydrogen, nitrogen, oxygen, phosphorous, sulfur, trace elements).
b. Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).
c. Explain how the properties of water (e.g., cohesion, adhesion, heat capacity, solvent properties) contribute to maintenance of cells and living organisms.
d. Explain the role of enzymes in cell chemistry.

Objective 2: Describe the flow of energy and matter in cellular function.

a. Distinguish between autotrophic and heterotrophic cells.
b. Illustrate the cycling of matter and the flow of energy through photosynthesis (e.g., by using light energy to combine CO_2 and H_2O to produce oxygen and sugars) and respiration (e.g., by releasing energy from sugar and O_2 to produce CO_2 and H_2O).
c. Measure the production of one or more of the products of either photosynthesis or respiration.

Objective 3: Investigate the structure and function of cells and cell parts.

a. Explain how cells divide from existing cells.
b. Describe cell theory and relate the nature of science to the development of cell theory (e.g., built upon previous knowledge, use of increasingly more sophisticated technology).
c. Describe how the transport of materials in and out of cells enables cells to maintain homeostasis (i.e., osmosis, diffusion, active transport).
d. Describe the relationship between the organelles in a cell and the functions of that cell.
e. Experiment with microorganisms and/or plants to investigate growth and reproduction.

Science language students should use:	organelles, photosynthesis, respiration, cellular respiration, osmosis, diffusion, active transport, homeostasis, cell theory, organic, carbohydrate, fermentation, protein, fat, nucleic acid, enzyme, chlorophyll, cell membrane, nucleus, cell wall, solvent, solute, adhesion, cohesion, microorganism

Science Benchmark

Structure relates to function. Organs and organ systems function together to provide homeostasis in organisms. The functioning of organs depends upon multiple organ systems.

Standard 3: Students will understand the relationship between structure and function of organs and organ systems.

Objective 1: Describe the structure and function of organs.

a. Diagram and label the structure of the primary components of representative organs in plants and animals (e.g., heart - muscle tissue, valves and chambers; lung - trachea, bronchial, alveoli; leaf - veins, stomata; stem - xylem, phloem, cambium; root - tip, elongation, hairs; skin - layers, sweat glands, oil glands, hair follicles; ovaries - ova, follicles, corpus luteum).
b. Describe the function of various organs (e.g. heart, lungs, skin, leaf, stem, root, ovary).
c. Relate the structure of organs to the function of organs.
d. Compare the structure and function of organs in one organism to the structure and function of organs in another organism.
e. Research and report on technological developments related to organs.

Objective 2: Describe the relationship between structure and function of organ systems in plants and animals.

a. Relate the function of an organ to the function of an organ system.
b. Describe the structure and function of various organ systems (i.e., digestion, respiration, circulation, protection and support, nervous) and how these systems contribute to homeostasis of the organism.
c. Examine the relationships of organ systems within an organism (e.g., respiration to circulation, leaves to roots) and describe the relationship of structure to function in the relationship.
d. Relate the tissues that make up organs to the structure and function of the organ.
e. Compare the structure and function of organ systems in one organism to the structure and function in another organism (e.g., chicken to sheep digestive system; fern to peach reproductive system).

Science language students should use:	organ, organ system, organism, hormonal modification, stomata, tissue, homeostasis, structure, function

Science Benchmark

Information passed from parent to offspring is coded in DNA (deoxyribonucleic acid) molecules. The fundamental DNA structure is the same for all living things; the sequence of DNA differs between each organism and each species. Changes in the DNA sequence may alter genetic expression. The genetic information in DNA provides the instructions for assembling protein molecules in cells. The code used is virtually the same for all organisms. There are predictable patterns of inheritance. Sexual reproduction increases the genetic variation of a species. Asexual reproduction provides offspring that have the same genetic code as the parent.

Standard 4: Students will understand that genetic information coded in DNA is passed from parents to offspring by sexual and asexual reproduction. The basic structure of DNA is the same in all living things. Changes in DNA may alter genetic expression.

Objective 1: Compare sexual and asexual reproduction.

a. Explain the significance of meiosis and fertilization in genetic variation.
b. Compare the advantages/disadvantages of sexual and asexual reproduction to survival of species.
c. Formulate, defend, and support a perspective of a bioethical issue related to intentional or unintentional chromosomal mutations.

Objective 2: Predict and interpret patterns of inheritance in sexually reproducing organisms.

a. Explain Mendel's laws of segregation and independent assortment and their role in genetic inheritance.
b. Demonstrate possible results of recombination in sexually reproducing organisms using one or two pairs of contrasting traits in the following crosses: dominance/recessive, incomplete dominance, codominance, and sex-linked traits.
c. Relate Mendelian principles to modern-day practice of plant and animal breeding.
d. Analyze bioethical issues and consider the role of science in determining public policy.

Objective 3: Explain how the structure and replication of DNA are essential to heredity and protein synthesis.

a. Use a model to describe the structure of DNA.
b. Explain the importance of DNA replication in cell reproduction.
c. Summarize how genetic information encoded in DNA provides instructions for assembling protein molecules.
d. Describe how mutations may affect genetic expression and cite examples of mutagens.
e. Relate the historical events that lead to our present understanding of DNA to the cumulative nature of science knowledge and technology.
f. Research, report, and debate genetic technologies that may improve the quality of life (e.g., genetic engineering, cloning, gene splicing).

Science language students should use:	DNA, replication, fertilization, dominant trait, recessive trait, genetic engineering, gene splicing, phenotype, genotype, sexual reproduction, asexual reproduction, chromosome, gene, mutation, cloning, inheritance, bioethics, pedigree

Science Benchmark

Evolution is central to modern science's understanding of the living world. The basic idea of biological evolution is that Earth's present day species developed from earlier species. Evolutionary processes allow some species to survive with little or no change, some to die out altogether, and other species to change, giving rise to a greater diversity of species. Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as science strives for explanations of the world.

Standard 5: Students will understand that biological diversity is a result of evolutionary processes.

Objective 1: Relate principles of evolution to biological diversity.

a. Describe the effects of environmental factors on natural selection.
b. Relate genetic variability to a species' potential for adaptation to a changing environment.
c. Relate reproductive isolation to speciation.
d. Compare selective breeding to natural selection and relate the differences to agricultural practices.

Objective 2: Cite evidence for changes in populations over time and use concepts of evolution to explain these changes.

a. Cite evidence that supports biological evolution over time (e.g., geologic and fossil records, chemical mechanisms, DNA structural similarities, homologous and vestigial structures).
b. Identify the role of mutation and recombination in evolution.
c. Relate the nature of science to the historical development of the theory of evolution.
d. Distinguish between observations and inferences in making interpretations related to evolution (e.g., observed similarities and differences in the beaks of Galapagos finches leads to the inference that they evolved from a common ancestor; observed similarities and differences in the structures of birds and reptiles leads to the inference that birds evolved from reptiles).
e. Review a scientific article and identify the research methods used to gather evidence that documents the evolution of a species.

Objective 3: Classify organisms into a hierarchy of groups based on similarities that reflect their evolutionary relationships.

a. Classify organisms using a classification tool such as a key or field guide.
b. Generalize criteria used for classification of organisms (e.g., dichotomy, structure, broad to specific).
c. Explain how evolutionary relationships are related to classification systems.
d. Justify the ongoing changes to classification schemes used in biology.

Science language students should use:	evolution, fossil record, geologic record, molecular, homologous, vestigial structures, mutation, recombination, hierarchy, classification scheme, theory, natural selection, adaptation, evidence, inference, speciation, biodiversity, taxonomy, kingdom, virus, protist, fungi, plant, animal, dichotomy

Chemistry Core Curriculum

The Chemistry Core Curriculum has two primary goals: (1) students will value and use science as a process of obtaining knowledge based on observable evidence, and (2) students' curiosity will be sustained as they develop the abilities associated with scientific inquiry.

Theme

Chemistry is organized around major concepts of matter, structure, energy, and change. The "Benchmarks" in the chemistry Core emphasize the principles and laws that describe the conservation of matter, changes in the structure of matter, and changes in energy. Substances can be described by their chemical structure or properties. Substances can be made of molecules and these molecules are made of atoms. The properties of water are very different from the properties of hydrogen or oxygen of which it is composed. When parts come together, the whole often has properties that are very different from its parts. The formation of compounds results in a great diversity of matter from a limited number of elements. When matter combines, energy is absorbed or released and matter is rearranged to make new substances with new properties.

The purpose of the Utah Chemistry Core Curriculum is to provide the minimum standards for all students to achieve basic scientific literacy in chemistry. The Core is written with the understanding that individual teachers may choose additional content and activities to meet the needs and interests of their own students.

Inquiry

Good science instruction requires hands-on science investigations in which student inquiry is an important goal. Students in chemistry should design and perform experiments, and value inquiry as the fundamental scientific process. Instruction should encourage students to maintain an open and questioning mind to pose their own questions about objects, events, processes, and results. They should have the opportunity to plan and conduct their own experiments, and come to their own conclusions as they read, observe, compare, describe, infer, and draw conclusions. The results of their experiments need to be compared for reasonableness to multiple sources of information. It is important for students at this age to begin to formalize the processes of science and be able to identify the variables in a formal experiment.

Relevance

Chemistry Core concepts should be integrated with concepts and skills from other curriculum areas. Reading, writing, and mathematics skills should be emphasized as integral to the instruction of science. Personal relevance of science in students' lives is an important part of helping students to value science and should be emphasized at this grade level. Developing students' writing skills in science should be an important part of science instruction in chemistry. Students should regularly write descriptions of their observations and experiments. Lab journals are an effective way to emphasize the importance of writing in science.

Providing opportunities for students to gain insights into science related careers adds to the relevance of science learning. Chemistry provides students with an opportunity to investigate careers in chemistry, environmental science, food science, atomic energy, engineering, and medicine. Resources related to careers in science may be found at the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science .

Character
Value for honesty, integrity, self-discipline, respect, responsibility, punctuality, dependability, courtesy, cooperation, consideration, and teamwork should be emphasized as an integral part of science learning. These relate to the care of living things, safety and concern for self and others, and environmental stewardship. Honesty in all aspects of research, experimentation, data collection, and reporting is an essential component of science.

Resources for Instruction
This Core was designed using the American Association for the Advancement of Science's *Project 2061: Benchmarks for Science Literacy* and the National Academy of Science's *National Science Education Standards* as guides to determine appropriate content and skills.

The Chemistry Core has many online resources designed to help with classroom instruction. The Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science is an ongoing report of resources available and aligned to the Chemistry Core Curriculum.

Safety Precautions and Appropriate Use and Disposal of Chemical
The hands-on nature of science learning increases the need for teachers to use appropriate precautions in the classroom, laboratory, and field. Proper handling and disposal of chemicals is crucial for safety of students and teacher. Prior to students working in the laboratory they should be required to demonstrate their understanding of safe laboratory practices. It is recommended that teachers use microchemistry techniques where appropriate. It is important that all students understand the rules for a safe classroom and laboratory. Field activities should be well thought out and use appropriate and safe practices. Teachers must adhere to the published guidelines for the proper use and disposal of chemicals in the classroom. These guidelines are available on the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science.

The Most Important Goal
Science instruction should cultivate and build on students' curiosity and sense of wonder. Effective science instruction engages students in enjoyable learning experiences. Science instruction should be as thrilling an experience for a student as watching the colors change in a chemical reaction or observing the formation of silver crystals on a copper wire in a solution of silver nitrate. Science is not just for those who have traditionally succeeded in the subject, and it is not just for those who will choose science-related careers. In a world of rapidly expanding knowledge and technology, all students must gain the skills they will need to understand and function responsibly and successfully in the world. The Core provides skills in a context that enables students to experience the joy of doing science.

Chemistry Core Curriculum

Science Benchmark

Matter on Earth and in the universe is made of atoms that have structure, mass, and a common origin. The periodic table is used to organize elements by structure. A relationship exists between the chemical behavior and the structure of atoms. The periodic table reflects this relationship.

The nucleus of an atom is a tiny fraction of the volume of the atom. Each proton or neutron in the nucleus is nearly 2,000 times the mass of an electron. Electrons move around the nucleus.

The modern atomic model has been developed using experimental evidence. Atomic theories describe the behavior of atoms as well as energy changes in the atom. Energy changes in an isolated atom occur only in discrete jumps. Change in structure and composition of the nucleus result in the conversion of matter into energy.

Standard 1: Students will understand that all matter in the universe has a common origin and is made of atoms, which have structure and can be systematically arranged on the periodic table.

Objective 1: Recognize the origin and distribution of elements in the universe.

a. Identify evidence supporting the assumption that matter in the universe has a common origin.
b. Recognize that all matter in the universe and on earth is composed of the same elements.
c. Identify the distribution of elements in the universe.
d. Compare the occurrence of heavier elements on earth and the universe.

Objective 2: Relate the structure, behavior, and scale of an atom to the particles that compose it.

a. Summarize the major experimental evidence that led to the development of various atomic models, both historical and current.
b. Evaluate the limitations of using models to describe atoms.
c. Discriminate between the relative size, charge, and position of protons, neutrons, and electrons in the atom.
d. Generalize the relationship of proton number to the element's identity.
e. Relate the mass and number of atoms to the gram-sized quantities of matter in a mole.

Objective 3: Correlate atomic structure and the physical and chemical properties of an element to the position of the element on the periodic table.

a. Use the periodic table to correlate the number of protons, neutrons, and electrons in an atom.
b. Compare the number of protons and neutrons in isotopes of the same element.
c. Identify similarities in chemical behavior of elements within a group.
d. Generalize trends in reactivity of elements within a group to trends in other groups.
e. Compare the properties of elements (e.g., metal, nonmetallic, metalloid) based on their position in the periodic table.

Standard 2: Students will understand the relationship between energy changes in the atom specific to the movement of electrons between energy levels in an atom resulting in the emission or absorption of quantum energy. They will also understand that the emission of high-energy particles results from nuclear changes and that matter can be converted to energy during nuclear reactions.

Objective 1: Evaluate quantum energy changes in the atom in terms of the energy contained in light emissions.

a. Identify the relationship between wavelength and light energy.
b. Examine evidence from the lab indicating that energy is absorbed or released in discrete units when electrons move from one energy level to another.
c. Correlate the energy in a photon to the color of light emitted.
d. After observing spectral emissions in the lab (e.g., flame test, spectrum tubes), identify unknown elements by comparison to known emission spectra.

Objective 2: Evaluate how changes in the nucleus of an atom result in emission of radioactivity.

a. Recognize that radioactive particles and wavelike radiations are products of the decay of an unstable nucleus.
b. Interpret graphical data relating half-life and age of a radioactive substance.
c. Compare the mass, energy, and penetrating power of alpha, beta, and gamma radiation.
d. Compare the strong nuclear force to the amount of energy released in a nuclear reaction and contrast it to the amount of energy released in a chemical reaction.
e. After researching, evaluate and report the effects of nuclear radiation on humans or other organisms.

Science language students should use:	atom, element, nucleus, proton, neutron, electron, isotope, metal, nonmetal, metalloid, malleable, conductive, periodic table, quanta, wavelength, radiation, emit, absorb, spectrum, half-life, fission, fusion, energy level, mole

Science Benchmark

Atoms form bonds with other atoms by transferring or sharing electrons. The arrangement of electrons in an atom, particularly the valence electrons, determines how an atom can interact with other atoms. The types of chemical bonds holding them together determine many of the physical properties of compounds. The formation of compounds results in a great diversity of matter from a limited number of elements.

Standard 3: Students will understand chemical bonding and the relationship of the type of bonding to the chemical and physical properties of substances.

Objective 1: Analyze the relationship between the valence (outermost) electrons of an atom and the type of bond formed between atoms.

a. Determine the number of valence electrons in atoms using the periodic table.
b. Predict the charge an atom will acquire when it forms an ion by gaining or losing electrons.
c. Predict bond types based on the behavior of valence (outermost) electrons.
d. Compare covalent, ionic, and metallic bonds with respect to electron behavior and relative bond strengths.

Objective 2: Explain that the properties of a compound may be different from those of the elements or compounds from which it is formed.

a. Use a chemical formula to represent the names of elements and numbers of atoms in a compound and recognize that the formula is unique to the specific compound.
b. Compare the physical properties of a compound to the elements that form it.
c. Compare the chemical properties of a compound to the elements that form it.
d. Explain that combining elements in different proportions results in the formation of different compounds with different properties.

Objective 3: Relate the properties of simple compounds to the type of bonding, shape of molecules, and intermolecular forces.

a. Generalize, from investigations, the physical properties (e.g., malleability, conductivity, solubility) of substances with different bond types.
b. Given a model, describe the shape and resulting polarity of water, ammonia, and methane molecules.
c. Identify how intermolecular forces of hydrogen bonds in water affect a variety of physical, chemical, and biological phenomena (e.g., surface tension, capillary action, boiling point).

Science language students should use:	chemical property, physical property, compound, valence electrons, ionic, covalent, malleability, conductivity, solubility, intermolecular, polarity

Science Benchmark

In a chemical reaction new substances are formed as atoms and molecules are rearranged. The concept of atoms explains the conservation of matter, since the number of atoms stays the same in a chemical reaction no matter how they are rearranged; the total mass stays the same. Although energy can be absorbed or released in a chemical reaction, the total amount of energy and matter in it remains constant. Many reactions attain a state of equilibrium. Many ordinary activities, such as baking, involve chemical reactions.

The rate of chemical reactions of atoms and molecules depends upon how often they encounter one another, which is a function of concentration, temperature, and pressure of the reacting materials. Catalysts can be used to change the rate of chemical reactions. Under proper conditions reactions may attain a state of equilibrium.

Standard 4: Students will understand that in chemical reactions matter and energy change forms, but the amounts of matter and energy do not change.

Objective 1: Identify evidence of chemical reactions and demonstrate how chemical equations are used to describe them.

a. Generalize evidences of chemical reactions.
b. Compare the properties of reactants to the properties of products in a chemical reaction.
c. Use a chemical equation to describe a simple chemical reaction.
d. Recognize that the number of atoms in a chemical reaction does not change.
e. Determine the molar proportions of the reactants and products in a balanced chemical reaction.
f. Investigate everyday chemical reactions that occur in a student's home (e.g., baking, rusting, bleaching, cleaning).

Objective 2: Analyze evidence for the laws of conservation of mass and conservation of energy in chemical reactions.

a. Using data from quantitative analysis, identify evidence that supports the conservation of mass in a chemical reaction.
b. Use molar relationships in a balanced chemical reaction to predict the mass of product produced in a simple chemical reaction that goes to completion.
c. Report evidence of energy transformations in a chemical reaction.
d. After observing or measuring, classify evidence of temperature change in a chemical reaction as endothermic or exothermic.
e. Using either a constructed or a diagrammed electrochemical cell, describe how electrical energy can be produced in a chemical reaction (e.g., half reaction, electron transfer).
f. Using collected data, report the loss or gain of heat energy in a chemical reaction.

Standard 5: Students will understand that many factors influence chemical reactions and some reactions can achieve a state of dynamic equilibrium.

Objective 1: Evaluate factors specific to collisions (e.g., temperature, particle size, concentration, and catalysts) that affect the rate of chemical reaction.

a. Design and conduct an investigation of the factors affecting reaction rate and use the findings to generalize the results to other reactions.
b. Use information from graphs to draw warranted conclusions about reaction rates.
c. Correlate frequency and energy of collisions to reaction rate.
d. Identify that catalysts are effective in increasing reaction rates.

Objective 2: Recognize that certain reactions do not convert all reactants to products, but achieve a state of dynamic equilibrium that can be changed.

a. Explain the concept of dynamic equilibrium.
b. Given an equation, identify the effect of adding either product or reactant to a shift in equilibrium.
c. Indicate the effect of a temperature change on the equilibrium, using an equation showing a heat term.

Science language students should use:	chemical reaction, matter, law of conservation of mass, law of conservation of energy, temperature, electrochemical cell, entropy, chemical equation, endothermic, exothermic, heat, rate, catalyst, concentration, collision theory, equilibrium, half reaction

Science Benchmark

Solutions make up many of the ordinary substances encountered in everyday life. The relative amounts of solutes and solvents determine the concentration and the physical properties of a solution. Two important categories of solutions are acids and bases.

Standard 6: Students will understand the properties that describe solutions in terms of concentration, solutes, solvents, and the behavior of acids and bases.

Objective 1: Describe factors affecting the process of dissolving and evaluate the effects that changes in concentration have on solutions.

a. Use the terms solute and solvent in describing a solution.
b. Sketch a solution at the particle level.
c. Describe the relative amount of solute particles in concentrated and dilute solutions and express concentration in terms of molarity and molality.
d. Design and conduct an experiment to determine the factors (e.g., agitation, particle size, temperature) affecting the relative rate of dissolution.
e. Relate the concept of parts per million (PPM) to relevant environmental issues found through research.

Objective 2: Summarize the quantitative and qualitative effects of colligative properties on a solution when a solute is added.

a. Identify the colligative properties of a solution.
b. Measure change in boiling and/or freezing point of a solvent when a solute is added.
c. Describe how colligative properties affect the behavior of solutions in everyday applications (e.g., road salt, cold packs, antifreeze).

Objective 3: Differentiate between acids and bases in terms of hydrogen ion concentration.

a. Relate hydrogen ion concentration to pH values and to the terms acidic, basic or neutral.
b. Using an indicator, measure the pH of common household solutions and standard laboratory solutions, and identify them as acids or bases.
c. Determine the concentration of an acid or a base using a simple acid-base titration.
d. Research and report on the uses of acids and bases in industry, agriculture, medicine, mining, manufacturing, or construction.
e. Evaluate mechanisms by which pollutants modify the pH of various environments (e.g., aquatic, atmospheric, soil).

Science language students should use:	solution, solute, solvent, concentration, molarity, percent concentration, colligative property, boiling point, freezing point, acid, base, pH, indicator, titration, hydrogen ion, neutralization, parts per million, concentrated, dilute, dissolve

Physics Core Curriculum

The Physics Core Curriculum has two primary goals: (1) students will value and use science as a process of obtaining knowledge based on observable evidence, and (2) students' curiosity will be sustained as they develop and refine the abilities associated with scientific inquiry.

Theme
The Physics Core has three major concepts for the focus of instruction: (1) motion of objects, (2) forces acting on objects, and (3) energy.

Inquiry
Physics students should design and perform experiments, and value inquiry as the fundamental scientific process. They should be encouraged to maintain an open and questioning mind, to pose their own questions about objects, events, processes, and results. They should have the opportunity to plan and conduct their own experiments, and come to their own conclusions as they read, observe, compare, describe, infer, and draw conclusions. The results of their experiments need to be compared for reasonableness to multiple sources of information. They should be encouraged to use reasoning as they apply physics concepts to their lives.

Scope
Not all possible physics topics are specified in the Core. Teachers may enhance their individual classes as they see opportunities to include more topics or more depth. The Physics Core is intended for teachers to help students understand basic physics concepts, develop scientific habits, and experience the process of scientific investigations. Good instruction requires hands-on investigations in which student inquiry is an important goal. Teachers should provide opportunities for **all** students to experience many things. Laboratory investigations should be frequent and meaningful components of physics instruction. Teachers should help students plan and conduct experiments in which they:

- Identify a problem.
- Formulate a research question and hypothesis.
- Identify variables and describe relationships between them.
- Plan procedures to control independent variables.
- Collect data on the dependent variable(s).
- Select the appropriate format (e.g., graph, chart, diagram) to summarize data obtained.
- Analyze data, check for accuracy, and construct reasonable conclusions.
- Prepare written and oral reports of investigations.

Students should enjoy science as a process of discovering and understanding the physical world.

Relevance
Physics Core concepts should be integrated with concepts and skills from other curriculum areas. Reading, writing, and mathematics skills should be emphasized as integral to the instruction of science. Personal relevance of science in students' lives is an important part of helping students to value science and should be emphasized at this grade level. Developing students' writing skills in science should be an important part of science instruction in physics. Students should regularly write descriptions of their observations and experiments. Lab journals are an effective way to emphasize the importance of writing in science.

Providing opportunities for students to gain insights into science related careers adds to the relevance of science learning. Physics provides students with an opportunity to investigate careers in physics, astronomy, engineering, aerospace, and energy. Resources related to careers in science may be found at the Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science .

Character
Value for honesty, integrity, self-discipline, respect, responsibility, punctuality, dependability, courtesy, cooperation, consideration, and teamwork should be emphasized as an integral part of science learning. These relate to the care of living things, safety and concern for self and others, and environmental stewardship. Honesty in all aspects of research, experimentation, data collection, and reporting is an essential component of science.
This Core was designed using the American Association for the Advancement of Science's *Project 2061: Benchmarks for Science Literacy* and the National Academy of Science's *National Science Education Standards* as guides to determine appropriate content and skills.

The Physics Core has many online resources designed to help with classroom instruction. The Utah Science Home Page at http://www.usoe.k12.ut.us/curr/science is an ongoing report of resources available and aligned to the Physics Core Curriculum.

Safety Precautions
The hands-on nature of science learning increases the need for teachers to use appropriate precautions in the classroom and field. It is important that all students understand the rules for a safe classroom.

The Most Important Goal
Science instruction should cultivate and build on students' curiosity and sense of wonder. Effective science instruction engages students in enjoyable learning experiences. Science instruction should be as thrilling an experience for a student as designing, building and testing catapults, bridges and rockets. Science is not just for those who have traditionally succeeded in the subject, and it is not just for those who will choose science-related careers. In a world of rapidly expanding knowledge and technology, all students must gain the skills they will need to understand and function responsibly and successfully in the world. The Core provides skills in a context that enables students to experience the joy of doing science.

Physics Core Curriculum

Science Benchmark

The motion of an object can be described by measurements of its position at different times. Velocity is a measure of the rate of change of position of an object. Acceleration is a measure of the rate of change of velocity of an object. This change in velocity may be a change in speed and/or direction. Motion is defined relative to the frame of reference from which it is observed. An object's state of motion will remain constant unless unbalanced forces act upon the object. This is Newton's first law of motion.

Standard 1: Students will understand how to measure, calculate, and describe the motion of an object in terms of position, time, velocity, and acceleration.

Objective 1: Describe the motion of an object in terms of position, time, and velocity.

a. Calculate the average velocity of a moving object using data obtained from measurements of position of the object at two or more times.
b. Distinguish between distance and displacement.
c. Distinguish between speed and velocity.
d. Determine and compare the average and instantaneous velocity of an object from data showing its position at given times.
e. Collect, graph, and interpret data for position vs. time to describe the motion of an object and compare this motion to the motion of another object.

Objective 2: Analyze the motion of an object in terms of velocity, time, and acceleration.

a. Determine the average acceleration of an object from data showing velocity at given times.
b. Describe the velocity of an object when its acceleration is zero.
c. Collect, graph, and interpret data for velocity vs. time to describe the motion of an object.
d. Describe the acceleration of an object moving in a circular path at constant speed (i.e., constant speed, but changing direction).
e. Analyze the velocity and acceleration of an object over time.

Objective 3: Relate the motion of objects to a frame of reference.

a. Compare the motion of an object relative to two frames of reference.
b. Predict the motion of an object relative to a different frame of reference (e.g., an object dropped from a moving vehicle observed from the vehicle and by a person standing on the sidewalk).
c. Describe how selecting a specific frame of reference can simplify the description of the motion of an object.

Objective 4: Use Newton's first law to explain the motion of an object.

a. Describe the motion of a moving object on which balanced forces are acting.
b. Describe the motion of a stationary object on which balanced forces are acting.
c. Describe the balanced forces acting on a moving object commonly encountered (e.g., forces acting on an automobile moving at constant velocity, forces that maintain a body in an upright position while walking).

Science language students should use:	position, time, speed, velocity, acceleration, distance, displacement, rate, instantaneous velocity, average velocity, frame of reference, balanced forces

Science Benchmark

Objects in the universe interact with one another by way of forces. Changes in the motion of an object are proportional to the sum of the forces, and inversely proportional to the mass. If one object exerts a force on a second object, the second object always exerts an equal and opposite force on the first object. Whenever a force is applied to an object there is an equal and opposite reaction force.

Any two objects in the universe with mass exert equal and opposite gravitational forces on one another. The electromagnetic force is manifested as an electric force, a magnetic force, or a combination. Any two objects in the universe with a net electric charge exert equal and opposite electric forces on one another. While gravitational forces are always attractive, electromagnetic forces can be either attractive or repulsive.

Friction, tension, compression, spring, gravitational, and normal forces are all common observable forces. The net force on an object is the vector sum of all the forces acting upon the object.

Standard 2: Students will understand the relation between force, mass, and acceleration.

Objective 1: Analyze forces acting on an object.

a. Observe and describe forces encountered in everyday life (e.g., braking of an automobile - friction, falling rain drops - gravity, directional compass - magnetic, bathroom scale - elastic or spring).
b. Use vector diagrams to represent the forces acting on an object.
c. Measure the forces on an object using appropriate tools.
d. Calculate the net force acting on an object.

Objective 2: Using Newton’s second law, relate the force, mass, and acceleration of an object.

a. Determine the relationship between the net force on an object and the object’s acceleration.
b. Relate the effect of an object’s mass to its acceleration when an unbalanced force is applied.
c. Determine the relationship between force, mass, and acceleration from experimental data and compare the results to Newton’s second law.
d. Predict the combined effect of multiple forces (e.g., friction, gravity, and normal forces) on an object’s motion.

Objective 3: Explain that forces act in pairs as described by Newton’s third law.

a. Identify pairs of forces (e.g., action-reaction, equal and opposite) acting between two objects (e.g., two electric charges, a book and the table it rests upon, a person and a rope being pulled).
b. Determine the magnitude and direction of the acting force when magnitude and direction of the reacting force is known.
c. Provide examples of practical applications of Newton’s third law (e.g., forces on a retaining wall, rockets, walking).
d. Relate the historical development of Newton’s laws of motion to our current understanding of the nature of science (e.g., based upon previous knowledge, empirical evidence, replicable observations, development of scientific law).

Standard 3: Students will understand the factors determining the strength of gravitational and electric forces.

Objective 1: Relate the strength of the gravitational force to the distance between two objects and the mass of the objects (i.e., Newton's law of universal gravitation).

a. Investigate how mass affects the gravitational force (e.g., spring scale, balance, or other method of finding a relationship between mass and the gravitational force).
b. Distinguish between mass and weight.
c. Describe how distance between objects affects the gravitational force (e.g., effect of gravitational forces of the moon and sun on objects on Earth).
d. Explain how evidence and inference are used to describe fundamental forces in nature, such as the gravitational force.
e. Research the importance of gravitational forces in the space program.

Objective 2: Describe the factors that affect the electric force (i.e., Coulomb's law).

a. Relate the types of charge to their effect on electric force (i.e., like charges repel, unlike charges attract).
b. Describe how the amount of charge affects the electric force.
c. Investigate the relationship of distance between charged objects and the strength of the electric force.
d. Research and report on electric forces in everyday applications found in both nature and technology (e.g., lightning, living organisms, batteries, copy machine, electrostatic precipitators).

Science language students should use:	force, electric force, electric charge, friction, gravitational force, mass, net force, normal force, weight, vector, vector diagram

Science Benchmark

The total energy of the universe is constant; however, the total amount of energy available for useful transformation is almost always decreasing. Energy can be converted from one form to another and move from one system to another. Transformation of energy usually produces heat that spreads to cooler places by radiation, convection, or conduction. Energy can be classified as potential or kinetic energy. Potential energy is stored energy and includes chemical, gravitational, electrostatic, elastic, and nuclear. Kinetic energy is the energy of motion.

Moving electric charges produce magnetic forces and moving magnets produce electric forces. The interplay of electric and magnetic forces is the basis for electric motors, generators, and many other modern technologies, including the production of electromagnetic waves. Modern electric generators produce electricity by converting mechanical energy into electrical energy.

Sound and light transfer energy from one location to another as waves. Characteristics of waves include wavelength, amplitude, and frequency. Waves can combine with one another, bend around corners, reflect off surfaces, be absorbed by materials they enter, and change direction when entering a new material. All these effects vary with wavelength. Observable waves include mechanical and electromagnetic waves. Mechanical waves transport energy through a medium. Electromagnetic radiation is differentiated by wavelength or frequency, and includes radio waves, microwaves, infrared, visible light, ultraviolet radiation, x-rays, and gamma rays. These wavelengths vary from radio waves (the longest) to gamma rays (the shortest). In empty space all electromagnetic waves move at the same speed, the "speed of light."

Standard 4: Students will understand transfer and conservation of energy.

Objective 1: Determine kinetic and potential energy in a system.

a. Identify various types of potential energy (i.e., gravitational, elastic, chemical, electrostatic, nuclear).
b. Calculate the kinetic energy of an object given the velocity and mass of the object.
c. Describe the types of energy contributing to the total energy of a given system.

Objective 2: Describe conservation of energy in terms of systems.

a. Describe a closed system in terms of its total energy.
b. Relate the transformations between kinetic and potential energy in a system (e.g., moving magnet induces electricity in a coil of wire, roller coaster, internal combustion engine).
c. Gather data and calculate the gravitational potential energy and the kinetic energy of an object (e.g., pendulum, water flowing downhill, ball dropped from a height) and relate this to the conservation of energy of a system.
d. Evaluate social, economic, and environmental issues related to the production and transmission of electrical energy.

Objective 3: Describe common energy transformations and the effect on availability of energy.

a. Describe the loss of useful energy in energy transformations.
b. Investigate the transfer of heat energy by conduction, convection, and radiation.
c. Describe the transformation of mechanical energy into electrical energy and the transmission of electrical energy.
d. Research and report on the transformation of energy in electrical generation plants (e.g., chemical to heat to electricity, nuclear to heat to mechanical to electrical, gravitational to kinetic to mechanical to electrical), and include energy losses during each transformation.

Standard 5: Students will understand the properties and applications of waves.

Objective 1: Demonstrate an understanding of mechanical waves in terms of general wave properties.

a. Differentiate between period, frequency, wavelength, and amplitude of waves.
b. Investigate and compare reflection, refraction, and diffraction of waves.
c. Provide examples of waves commonly observed in nature and/or used in technological applications.
d. Identify the relationship between the speed, wavelength, and frequency of a wave.
e. Explain the observed change in frequency of a mechanical wave coming from a moving object as it approaches and moves away (i.e., Doppler effect).
f. Explain the transfer of energy through a medium by mechanical waves.

Objective 2: Describe the nature of electromagnetic radiation and visible light.

a. Describe the relationship of energy to wavelength or frequency for electromagnetic radiation.
b. Distinguish between the different parts of the electromagnetic spectrum (e.g., radio waves and x-rays or visible light and microwaves).
c. Explain that the different parts of the electromagnetic spectrum all travel through empty space and at the same speed.
d. Explain the observed change in frequency of an electromagnetic wave coming from a moving object as it approaches and moves away (i.e., Doppler effect, red/blue shift).
e. Provide examples of the use of electromagnetic radiation in everyday life (e.g., communications, lasers, microwaves, cellular phones, satellite dishes, visible light).

Science language students should use:	energy, potential energy, kinetic energy, law of conservation of energy, wave, mechanical wave, electromagnetic wave, electromagnetic spectrum, wavelength, frequency, amplitude, period, reflection, refraction, diffraction, Doppler effect, elastic potential energy, medium, radio wave, microwave, infrared, visible light, ultraviolet, x-ray, gamma ray, conduction, convection, radiation