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LOUISIANA SCIENCE FRAMEWORK

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Schools That Work: Setting Higher Standards for Our Students

Rapid changes are occurring in our world and economy. The increasing complexity of work that spans the entire workforce of today's society demands that education for all students be made more relevant and useful to future careers. In response to these demands, Louisiana educators and citizens collaborated to develop an action plan to establish content standards that would raise the academic expectations of students. **Their mission was “to develop rigorous and challenging standards that will enable all Louisiana students to become lifelong learners and productive citizens for the 21st century.”** These higher academic standards and their accompanying benchmarks, which further define the standards, require students to extend the learning they have acquired by applying knowledge and skills to real life and work situations.

To prepare Louisiana students to meet the demands of society in the 21st century, the higher standards were designed to address content knowledge and application of skills. The standards focus on what students should know and be able to do. They promote and develop thinking processes which students will use in both classroom and real world situations and address the diversity of educational needs of all Louisiana students.

These content standards have been developed for all Louisiana students, including students with disabilities, gifted and talented students, as well as linguistically and culturally diverse students. Modifications for addressing their specific needs regarding curricula and instruction will be addressed through the local education agencies (LEAs).

Louisiana has made significant strides toward improving the education of our children. Our goal is to build on our strengths as we continue to improve education in our state. By developing rigorous standards and challenging assessments that align with the standards and by holding schools accountable for results, we are ensuring a better future for all our children.

Your partner for better education,

Cecil J. Picard
State Superintendent of Education

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SECTION 1: INTRODUCTION

LOUISIANA CONTENT STANDARDS FOUNDATION SKILLS

The Louisiana Content Standards Task Force has developed the following foundation skills which should apply to all students in all disciplines:

1. **Communication**: A process by which information is exchanged and a concept of “meaning” is created and shared between individuals through a common system of symbols, signs, or behavior. Students should be able to communicate clearly, fluently, strategically, technologically, critically, and creatively in society and in a variety of workplaces. This process can best be accomplished through use of the following skills: reading, writing, speaking, listening, viewing, and visually representing.
2. **Problem Solving**: The identification of an obstacle or challenge and the application of knowledge and thinking processes which include reasoning, decision making, and inquiry in order to reach a solution using multiple pathways, even when no routine path is apparent.
3. **Resource Access and Utilization**: The process of identifying, locating, selecting, and using resource tools to help in analyzing, synthesizing, and communicating information. The identification and employment of appropriate tools, techniques, and technologies are essential in all learning processes. These resource tools include pen, pencil, and paper; audio/video material, word processors, computers, interactive devices, telecommunication, and other emerging technologies.
4. **Linking and Generating Knowledge**: The effective use of cognitive processes to generate and link knowledge across the disciplines and in a variety of contexts. In order to engage in the principles of continued improvement, students must be able to transfer and elaborate on these processes. “Transfer” refers to the ability to apply a strategy or content knowledge effectively in a setting or context other than that in which it was originally learned. “Elaboration” refers to monitoring, adjusting, and expanding strategies into other contexts.

5. **Citizenship**: The application of the understanding of the ideals, rights, and responsibilities of active participation in a democratic republic that includes working respectfully and productively together for the benefit of the individual and the community; being accountable for one's choices and actions and understanding their impact on oneself and others; knowing one's civil, constitutional, and statutory rights; and mentoring others to be productive citizens and lifelong learners.

Note: These foundation skills are listed numerically in parentheses at the end of each benchmark.

INFORMATION LITERACY MODEL FOR LIFELONG LEARNING

Students must become competent and independent users of information to be productive citizens of the 21st century. They must be prepared to live in an information-rich and changing global society. Due to the rapid growth of technology, the amount of information available is accelerating so quickly that teachers are no longer able to impart a complete knowledge base in a subject area. In addition, students entering the workforce must know how to access information, solve problems, make decisions, and work as part of a team. Therefore, information literacy -- the ability to recognize an information need and then locate, evaluate, and effectively use the needed information -- is a basic skill essential to the 21st century workplace and home. Information literate students are self-directed learners who, individually or collaboratively, use information responsibly to create quality products and to be productive citizens. Information literacy skills must not be taught in isolation; they must be integrated across all content areas, utilizing fully the resources of the classroom, the school library media center, and the community. The Information Literacy Model for Lifelong Learners is a framework that teachers at all levels can apply to help students become independent lifelong learners.

1. **Defining/Focusing:** The first task is to recognize that an information need exists. Students make preliminary decisions about the type of information needed based on prior knowledge.
2. **Selecting Tools and Resources:** After students decide what information is needed, they then develop search strategies for locating and accessing appropriate, relevant sources in the school library media center, community libraries and agencies, resource people, and others as appropriate.
3. **Extracting and Recording:** Students examine the resources for readability, currency, usefulness, and bias. This task involves skimming or listening for key words, “chunking” reading, finding main ideas, and taking notes.
4. **Processing Information:** After recording information, students must examine and evaluate the data in order to utilize the information retrieved. Students must interact with the information by categorizing, analyzing, evaluating, and comparing for bias, inadequacies, omissions, errors, and value judgments. Based on their findings, they either move on to the next step or do additional research.

5. **Organizing Information:** Students effectively sort, manipulate, and organize the information that was retrieved. They make decisions on how to use and communicate their findings.
6. **Presenting Findings:** Students apply and communicate what they have learned (e.g., research report, project, illustration, dramatization, portfolio, book, book report, map, oral/audio/visual presentation, game, bibliography, hyperstack).
7. **Evaluating Efforts:** Throughout the information problem solving process, students evaluate their efforts. This assists students in determining the effectiveness of the research process. The final product may be evaluated by the teacher and also other qualified or interested resource persons.

PHILOSOPHY OF SCIENCE EDUCATION

Science education in Louisiana must prepare students to become informed citizens who have acquired the necessary scientific and technological knowledge and skills to function responsibly in the global community of the 21st century. It is essential that everyone involved in science education provide an opportunity for all students to become scientifically literate and reflective of the inherent nature of scientific knowledge, methods, and processes.

Scientific knowledge should be constructed through a hands-on/minds-on approach with overarching concepts that connect the sciences and other disciplines. Methodology and teaching strategies should be inquiry-based and include hands-on/minds-on activities. Assessment should reflect this inquiry-based curriculum and instruction and be used to improve teaching and learning. It is the responsibility of the entire community to be involved in science education reform efforts. This widespread involvement should encourage students of this state to become life-long learners.

NEED AND CONTEXT FOR REFORM

Over the past decade, due in part to Science for All Americans, published by the American Association for the Advancement of Science, educators across the country have reexamined the purposes of and approaches to science education. A major impetus for this critical look is our ever-changing society. Science and mathematics are increasingly important, as they provide a basis for citizens to make informed decisions and to earn a living in a scientific and technological world.

The movement to reform science education focuses on science literacy for all students. Project 2061 Update 1994 defines scientifically literate persons as those “equipped with the knowledge and skills they need to make sense of how the world works, to think critically and independently, and to lead responsible and productive lives in a culture increasingly shaped by science and technology” (American Association for the Advancement of Science [AAAS], 1994, p. 6). This intent of science literacy for everyone is reflected in the following national education goals originally put forward by the National Governor's Association:

- ! American students will leave grades four, eight, and twelve having demonstrated competency over challenging subject matter including English, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography.

- ! U.S. students will be first in the world in mathematics and science achievement.

- ! Every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and to exercise the rights and responsibilities of citizenship.

A number of national initiatives have helped to establish new perspectives and resources for reforming science education. The National Science Foundation's (NSF) Statewide Systemic Initiatives program funded selected states' efforts to make extensive changes in mathematics and science education. The American Association for the Advancement of Science established Project 2061, a long-range reform project that identifies key concepts in science, mathematics, and technology. The National Research Council, a division of the National Academy of Science, published the National Science Education Standards for Grades K-12 in 1996; and the National Science Teachers Association developed the Scope, Sequence, and Coordination project to implement reform approaches in secondary science classrooms.

It has become clear that the current approaches to science education must be reformed to meet the need for a scientifically literate citizenry and workforce. This reform effort in Louisiana began with a successful application to establish an NSF-funded statewide systemic initiative. A broad-based coalition of Louisianians secured a five-year, \$10 million grant for the Louisiana Systemic Initiatives Program (LaSIP). Louisiana provided matching funds from the Louisiana Board of Elementary and Secondary Education (LBESE) and the Louisiana Board of Regents (LBoR) for colleges and universities to support the work of reforming mathematics and science education.

The Louisiana Department of Education (LDE) was awarded a Dwight D. Eisenhower National Program for Mathematics and Science Education grant from the United States Department of Education. This grant enabled the LDE, in collaboration with LaSIP, to develop the Louisiana Mathematics and Science Curriculum and Assessment Frameworks.

PURPOSE OF THE FRAMEWORK

This Framework document articulates, organizes, and integrates the content and processes of science education. It serves as a bridge between classroom practices and the national standards established by the science education community, as the standards define what a scientifically literate person should know, understand, and be able to do. It reflects research in science education as it outlines instructional content, teaching methodologies, and assessment strategies.

The Louisiana Science Framework is designed to guide the process of reforming science education in this state. It provides the following:

- ! a master plan for developing the scientific literacy of Louisiana's students as they progress from kindergarten through Grade 12;
- ! a design for science education that meets Louisiana's specific needs;
- ! a catalyst for insightful discussion of the fundamental nature of science;
- ! a guide for evaluating progress in achieving scientific literacy among the students of Louisiana; and
- ! a vision of science education for the state and a tool to enable local districts, schools, and educators to grasp the nature, purpose, and role of science education.

Intended Audiences

This Framework, including the Introduction, Teaching and Learning of Science, Assessment, and Content Standards, is intended to be used mainly by teachers and curriculum developers to plan curriculum, instruction, and assessment for teachers and students.

The Introduction and Teaching and Learning of Science sections of the Framework can be used by a broad audience as a reference point to achieve a common vision of what and how science should be taught in Louisiana schools. The Framework does not address issues such as Standards for the Professional Development for Teachers of Science, Science Education Program Standards, and Science Education System Standards. The National Science Education Standards (NSES) includes standards and information on the above topics, as well as Science and Technology, Science in Personal and Social Perspective, and History and Nature of Science. Anyone interested in professional development, program, or system standards should obtain a copy of the NSES. Anyone looking at the NSES for the first time should be sure to look at the Changing Emphases pages at the end of each section, which give an overview of the kinds of changes needed in standards-based science education.

Intended Use

This Framework serves as a guide for curriculum and instruction and as a general reference to the basic principles of science education.

Intended uses for this Framework include the following:

- ! **for teachers and curriculum developers, a guide for planning curriculum, instruction, and assessment;**
- ! **for parents, a means for assessing the effectiveness of their children's science education;**
- ! **for administrators and school board members, a vision for science education and a basis for planning resource allocations, material purchases, local curriculum development, and teachers' professional development;**
- ! **for policy makers and state education staffs, a basis for developing laws, policies, and funding priorities to support local reforms;**
- ! **for staff developers, a basis for creating professional development materials and strategies designed to increase teachers' knowledge of science content, teaching methodologies, and assessment strategies;**
- ! **for assessment specialists and test developers, a guide for the development of an assessment framework to assess students' scientific understanding and ability more effectively;**
- ! **for colleges and universities, a guide for content and design of teacher preparation programs; and**
- ! **for business and industry leaders and governmental agencies, a basis for developing effective partnerships and local reforms for funding instructional materials and professional development.**

SECTION II: THE TEACHING AND LEARNING OF SCIENCE

NATURE OF SCIENCE

Science is a way of thinking and a system of knowledge that uses reason, observation, experimentation, and imagination. The goal of science is to describe, explain, and predict natural phenomena and processes. Science shares some characteristics with other forms of scholarly inquiry, but it is unique in several important ways. Science attempts to meet the criteria of testability, objectivity, and consistency. Scientific information is continuously open to review and modification; science is not a static body of knowledge. One of the functions of science education is to teach students to understand scientific information and the processes by which it was derived.

Science is a complex social activity. Scientific knowledge is generated not only by individuals but also by scientists who work cooperatively in laboratories and in the field. For scientific ideas to become widely accepted, peers must review, analyze, and critique results through journal articles, replication of experiments, and presentations at professional meetings. This process has implications for the way science is taught. It suggests the importance of working in cooperative groups, recording and presenting laboratory and field results, debating issues, and posing new questions based on current findings.

Scientists generally work with theories, which are explanations or predictions drawn from analyses of past scientific results. Investigations of the validity of a theory may take many different forms, including observing, collecting specimens and data for analysis, and conducting experiments.

Few scientists actually follow the orderly steps of what is known as the “scientific method.” Instead, they may omit, move, or augment one or more of these steps. Scientists' explanations about what happens in the world come partly from what they observe and partly from what they infer; sometimes scientists have different explanations for the same set of observations. Scientists also use their imaginations to consider possible causes or outcomes: A number of scientific discoveries have been based on a scientist's idea, which was then tested for validity. It is always important for scientists to consider their own biases or preconceptions and to seek to eliminate these from their work.

UNIFYING CONCEPTS AND PROCESSES

Science, mathematics, and technology are crosscut by big ideas that transcend disciplinary boundaries. They are useful in teaching as a means of organizing science content in ways that are meaningful for students and that promote interdisciplinary instruction. Current approaches to science teaching emphasize the need to convey “big ideas” rather than isolated facts that may not fit into any meaningful pattern for the student. When instruction is organized around large concepts, it is easier for students to find meaning in specific facts and to relate them to the larger concepts presented.

Unifying concepts and processes provide students with powerful ideas to help them understand the natural world. These include, but are not limited to, the following:

- ! systems, order, and organization;
- ! evidence, models, and explanation;
- ! change, constancy, and measurement; and
- ! form and function.

INSTRUCTIONAL ISSUES

The purpose of science education is not for students to memorize the "right" answer, but for them to move along a learning continuum toward a deeper understanding of science concepts and processes. Current research indicates that it is best for understanding to be constructed actively by the learner. This learning style offers a new role for the science teacher as a facilitator of learning versus an imparter of knowledge. Instruction should minimize rote learning and focus on in-depth understanding of major concepts and topics, with students actively exploring those ideas through activities they can relate to their own lives. Students often work cooperatively in small groups to exchange and critique their own ideas, with the teacher facilitating discussion rather than providing answers. Science is presented as a human enterprise and a continuing process for extending understanding, instead of the ultimate, unalterable truth. Learning activities are often interdisciplinary, stressing the connections between the sciences and other subjects. Science teachers must have a solid understanding of the basic concepts and processes of science in order to construct meaningful science activities that address all students' diverse experiences and learning styles.

During the last decade, a major change has occurred in science educators' views about how science learning takes place. The science education research community now views effective science teaching as helping the learner build upon prior knowledge to construct a scientific understanding of the phenomena being studied -- making learning a lifelong construction project.

Research studies have shown that students begin school not as "blank slates," but with a substantial set of ideas about how the world functions. These ideas usually have developed without any exposure to formal science instruction, but rather through observation, guesswork, and bits of information filtered down from adults and other children. Students often form misconceptions about such basic processes as why the seasons change, how gravity works, and what electricity is. The most important finding from these research studies is not that students have preconceptions about science, but that their misconceptions are deeply rooted and tenacious.

To address this instructional dilemma, teachers need to elicit students' ideas and then allow the students to test their ideas against scientific knowledge and thereby construct their own understanding. It is important to underscore that the learners must do the constructing, not the teacher. The teacher should choose excellent teaching activities and materials, but it is the learner who must actively connect the new knowledge to what he or she already knows.

Activities or processes that facilitate this construction of knowledge are listed below in three broad categories:

Using Knowledge

- describing
- explaining
- predicting
- designing
- analyzing

Constructing New Knowledge

- asking questions
- solving problems
- interpreting text
- reconstructing knowledge

Reflecting on Knowledge

justifying
criticizing
describing limits
making connections
taking perspectives
describing interactions

(Michigan State Board of Education, 1991).

These activities will offer students the opportunity to dispel their misconceptions as they continually construct new scientific knowledge.

TECHNOLOGY

Just as science is both a process and content, so is technology. As a process, technology is the using of scientific knowledge and other resources to develop new products and processes. “[T]he relationship between science and technology is so close that any presentation of science without developing understanding of technology would portray an inaccurate picture of science” (National Science Education Standards Draft [Standards], 1994, pp. v-153).

While the emphasis in science is on gaining knowledge of the natural world, the emphasis in technology is on finding practical ways to apply that knowledge to solve problems. “Science helps drive technology, as it provides knowledge for better understanding, instruments, and techniques. Technology is essential to science because it enables observations of phenomena that are far beyond the capabilities of scientists due to factors such as distance, location, size, and speed and provides tools for investigations, inquiry, and analysis” (NSE Standards, pp. v-95).

The emphasis of technology in the classroom should be on knowledge construction to solve problems. The posing and solving of problems that are increasingly complex will enable students to develop skills that are vital to living in a technical world.

Students should develop an awareness and appreciation for the continuing progress in technology as it affects the quality of individual lives as well as society, in order to become better informed citizens and consumers and become computer literate and proficient, as it applies to the computer’s capability to acquire data (with sensors), interpret data (by graphing), and as a research tool (library and Internet).

MATERIALS AND EQUIPMENT

Instructional materials and equipment can increase students' interest and improve achievement; they deserve a prominent place in science programs. Students should have access to materials and equipment and be offered opportunities to learn to use them effectively. It is essential that classroom teachers have the necessary nonconsumable and consumable materials and equipment provided and that they be maintained and/or replenished.

SCIENCE AND EQUITY

The reform emphasis on science literacy has no boundaries. It excludes no one regardless of gender, race, ethnicity, and socioeconomic status. Unfortunately, because this has not always been the case in science education, it is not reflected in the enrollment in high school science classes and in the adult workforce of scientists. "To neglect the science education of any (as has happened too often to girls and minority students) is to deprive them of a basic education . . . and deprive the nation of talented workers and informed citizens -- a loss the nation can ill afford" (Science for All Americans, 1989, pp. 156-157).

It is imperative that reform science education in Louisiana include hands-on, inquiry-based science teaching that will develop thinking skills in all students for a lifetime of use. Preconceived notions that science has a very narrow scope and that it is limited to a select few can be dispelled by developing critical thinking skills in all students and by developing the practice of using these thinking skills in every area of life involving cognitive processes. Development of these skills begins with kindergarten science explorations. Memorizing science facts will not suffice. It is critical that appropriate instructional tools be provided for all students so that this type of inquiry-based instruction can be implemented.

However, this philosophy is not enough to address the equity issue. Science education must also include keeping students in contact with culturally appropriate role models and career information. Reform efforts must dispel preconceived notions about who can be a scientist. All students must become aware of their own abilities to achieve in science. The content and methods of the Louisiana Science Framework reflect careful consideration of equity to assure that all students are provided the opportunity to succeed in learning science.

SECTION III: ASSESSMENT

PURPOSE

“Assessment is a systemic, multi-step process involving the collection and interpretation of educational data” (NSE Standards, p. 76). The purpose of assessment is to provide information to all the stakeholders in order to improve teaching and learning. Teachers, students, and parents need feedback on student progress. School administrators, educational planners, and the community need information to determine the overall effectiveness of the science program. As science instruction moves from a focus on facts to a focus on in-depth understanding of major concepts and processes, the assessment of science learning also must change.

CLASSROOM ASSESSMENT

Assessment serves many important purposes in the science classroom: diagnostic (to plan instruction to fit the student's prior knowledge), formative (to improve performance and adapt instruction), and summative (to report on final performance). The purpose of the assessment determines the assessment technique.

1. Assessment should parallel instruction. As science education develops toward a hands-on, inquiry-based approach to learning, assessments will need to become more activity-based.
2. Assessment should be fair and equitable. Throughout the learning process, expectations should be clearly articulated to students. Assessment activities that measure skills beyond recall of facts should be challenging and thoughtful; however, all students should be given learning opportunities that enable them to apply concepts and skills successfully. In order to determine what students know and are able to do as a result of science instruction, teachers must develop assessments that are free of gender, racial, and language barriers.
3. Assessment should include data from multiple sources. Varied assessment strategies provide opportunities for teachers to observe students as they conduct a variety of tasks in different settings. Student-generated products from group work, entries from individual science journals, student-designed investigations and exhibitions, and

student-constructed written responses are rich sources of data that enable teachers to determine students' understanding of science concepts and processes.

Assessment should encourage the development of higher order thinking skills; therefore, assessment must be designed to require students not just to recall random facts, but to demonstrate scientific problem-solving and conceptual knowledge. New designs for assessment must encourage forms of active assessment that are imbedded in instruction.

LARGE-SCALE ASSESSMENT

Large-scale assessment refers to assessment at the district, state, and national level. These external assessments are conducted for the purpose of providing the following:

- ! information for policy makers;**
- ! data for program evaluation;**
- ! a measure of pupil progression;**
- ! data for district, state, and national comparisons; and**
- ! a criterion for graduation.**

Assessment can have a powerful influence on curriculum and instruction; therefore, the utilization of assessment techniques that closely parallel effective instructional activities and outcomes are beneficial in the science classroom.

SECTION IV: CONTENT STRANDS

The Science Framework is divided into five strands: Science as Inquiry, Physical Science, Life Science, Earth and Space Science, and Science and the Environment. Each of the strands is organized into grade clusters and introduced with a focus statement that describes important aspects inherent to that section, followed by a standard (overarching goal) and benchmarks. Benchmarks, for the purpose of this document, are defined as broad statements of process and/or content that are to be used as a reference to develop curriculum and assess student progress. They are based on the National Science Education Standards and reflect the goal of increased science literacy for all students. The benchmarks were designed to provide breadth and continuity of content throughout the K-12 curriculum, while allowing for the flexibility of instruction in the individual classroom.

The first strand, Science as Inquiry, centers on the scientific process of inquiry, which citizens continually practice as they seek to understand issues, solve problems, and make decisions in everyday life. It is included in the benchmarks -- along with the subject matter in Physical Science, Life Science, Earth and Space Science, and Science and the Environment -- to emphasize the importance of the processes of science. It is envisioned that integration of the strands will occur and that there will be integration across the sciences and other disciplines.

To assist the teacher, handbooks that consist of the Framework, a sample module, and selected activities are under development for Grades K-8. The learning modules are designed as models and are provided for the grade clusters of K-2, 3-4, and 5-8. They consist of readings for teachers and students, a vignette, teaching materials, and learning activities that integrate assessment into the instruction. These modules are designed to aid in the transfer of the broad benchmarks into classroom instruction. The handbook is intended to assist in the development of curriculum and teaching methods that promote science literacy for all students.

SCIENCE AS INQUIRY

FOCUS

The process of scientific inquiry involves “asking a question, planning and conducting an investigation, using appropriate tools, mathematics, and techniques, thinking critically and logically about the relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments” (NSE Standards, pp. v-4). Students develop these skills as they are encouraged to think scientifically rather than simply memorize and/or study science facts.

STANDARD

The students will do science by engaging in partial and full inquiries that are within their developmental capabilities.

BENCHMARKS K-4

In Grades K-4, what students know and are able to do includes:

A. THE ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

- SI-E-A1 asking appropriate questions about organisms and events in the environment;
(1, 3)
- SI-E-A2 planning and/or designing and conducting a scientific investigation;
(2, 3)
- SI-E-A3 communicating that observations are made with one's senses;
(1, 3)
- SI-E-A4 employing equipment and tools to gather data and extend the sensory observations;
(3)
- SI-E-A5 using data, including numbers and graphs, to explain observations and experiments;

(1, 2, 3)

SI-E-A6 communicating observations and experiments in oral and written formats;
(1, 3)

SI-E-A7 utilizing safety procedures during experiments.
(3, 5)

B. UNDERSTANDING SCIENTIFIC INQUIRY

SI-E-B1 categorizing questions into what is known, what is not known, and what questions need to be explained;
(2, 4)

SI-E-B2 using appropriate experiments depending on the questions to be explored;
(2, 4)

SI-E-B3 choosing appropriate equipment and tools to conduct an experiment;
(2, 3, 5)

SI-E-B4 developing explanations by using observations and experiments;
(1, 2, 3, 4)

SI-E-B5 presenting the results of experiments;
(1, 3)

SI-E-B6 reviewing and asking questions about the results of investigations.
(1, 3, 4)

BENCHMARKS 5-8

As students in Grades 5-8 extend their knowledge, what they know and are able to do includes:

A. THE ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

SI-M-A1 identifying questions that can be used to design a scientific investigation;
(1, 2, 3)



SI-M-A2 **designing and conducting a scientific investigation;**
(1, 2, 3, 4, 5)

SI-M-A3 using mathematics and appropriate tools and techniques to gather, analyze, and interpret data;
(1, 2, 3, 4, 5)

SI-M-A4 developing descriptions, explanations, and graphs using data;
(1, 2, 3, 4)



SI-M-A5 **developing models and predictions using the relationships between data and explanations;**
(1, 2, 3, 4)



SI-M-A6 **comparing alternative explanations and predictions;**
(1, 3, 4)



SI-M-A7 **communicating scientific procedures, information, and explanations;**
(1, 3)

SI-M-A8 utilizing safety procedures during scientific investigations.
(3, 5)

B. UNDERSTANDING SCIENTIFIC INQUIRY

SI-M-B1 recognizing that different kinds of questions guide different kinds of scientific investigations;
(2, 4)

- SI-M-B2** communicating that current scientific knowledge guides scientific investigations;
(1, 3, 4)
- SI-M-B3** understanding that mathematics, technology, and scientific techniques used in an experiment can limit or enhance the accuracy of scientific knowledge;
(3, 4)
- SI-M-B4** using data and logical arguments to propose, modify, or elaborate on principles and models;
(1, 2, 3, 4)
- SI-M-B5** understanding that scientific knowledge is enhanced through peer review, alternative explanations, and constructive criticism;
(1, 4, 5)
- SI-M-B6** communicating that scientific investigations can result in new ideas, new methods or procedures, and new technologies;
(1, 3, 4)
- SI-M-B7** understanding that scientific development/technology is driven by societal needs and funding.
(4, 5)

BENCHMARKS 9-12

As students in Grades 9-12 extend their knowledge, what they know and are able to do includes:

A. THE ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY

SI-H-A1 identifying questions and concepts that guide scientific investigations;
(2, 4)



SI-H-A2 designing and conducting scientific investigations;
(1, 2, 3, 4, 5)

SI-H-A3 using technology and mathematics to improve investigations and communications;

(1, 2, 3)

SI-H-A4 **formulating and revising scientific explanations and models using logic and evidence;**
(1, 2, 3, 4)



SI-H-A5 **recognizing and analyzing alternative explanations and models;**
(4)



SI-H-A6 **communicating and defending a scientific argument;**
(1, 3, 4)

SI-H-A7 **utilizing science safety procedures during scientific investigations.**
(3, 5)

B. UNDERSTANDING SCIENTIFIC INQUIRY

SI-H-B1 **communicating that scientists usually base their investigations on existing models, explanations, and theories;**
(1, 3, 4)

SI-H-B2 **communicating that scientists conduct investigations for a variety of reasons, such as exploration of new areas, discovery of new aspects of the natural world, confirmation of prior investigations, evaluation of current theories, and comparison of models and theories;**
(1, 3, 4)

SI-H-B3 **communicating that scientists rely on technology to enhance the gathering and manipulation of data;**
(1, 3)



SI-H-B4 **analyzing a proposed explanation of scientific evidence according to the following criteria: follow a logical structure, follow rules of evidence, allow for questions and modifications, and is based on historical and current scientific knowledge;**
(2, 4, 5)

SI-H-B5 communicating that the results of scientific inquiry, new knowledge, and methods emerge from different types of investigations and public communication among scientists.
(1, 3, 4, 5)

PHYSICAL SCIENCE

FOCUS

Exploring the characteristics, forces, and changes in objects and materials encourages students to develop an understanding of the world in which they live to establish a basis for a lifelong study of their world. As students increase their understanding and abilities, they will be able to use more sophisticated qualitative and quantitative methods to construct and analyze information. This study will enable them to make informed decisions based on a better understanding of how things work in the physical world.

STANDARD

Students will develop an understanding of the characteristics and interrelationships of matter and energy in the physical world.

BENCHMARKS K-4

In Grades K-4, what students know and are able to do includes:

A. PROPERTIES OF OBJECTS AND MATERIALS

- PS-E-A1 observing, describing, and classifying objects by properties (size, weight, shape, color, texture, and temperature);
(4)
- PS-E-A2 measuring properties of objects using appropriate materials, tools, and technology;
(3, 4, 5)
- PS-E-A3 observing and describing the objects by the properties of the materials from which they are made (paper, wood, metal);
(2, 4)
- PS-E-A4 describing the properties of the different states of matter and identifying the conditions that cause matter to change states;
(2, 3)

PS-E-A5 creating mixtures and separating them based on differences in properties (salt, sand).
(2, 3)

B. POSITION AND MOTION OF OBJECTS

PS-E-B1 observing and describing the position of an object relative to another object or the background;
(1, 2)

PS-E-B2 exploring and recognizing that the position and motion of objects can be changed by pushing or pulling (force) over time;
(1, 2, 3)

PS-E-B3 describing an object's motion by tracing and measuring its position over time;
(1, 2, 3, 4)



PS-E-B4 investigating and describing how the motion of an object is related to the strength of the force (pushing or pulling) and the mass of the object.
(1, 2, 3, 4)

C. FORMS OF ENERGY



PS-E-C1 experimenting and communicating how vibrations of objects produce sound and how changing the rate of vibration varies the pitch;
(2)



PS-E-C2 investigating and describing how light travels and what happens when light strikes an object (reflection, refraction, and absorption);
(2)



PS-E-C3 investigating and describing different ways heat can be produced and moved from one object to another by conduction;
(2)



PS-E-C4 investigating and describing how electricity travels in a circuit;
(2)

- PS-E-C5 **investigating and communicating that magnetism and gravity can exert forces on objects without touching the objects;**
(2)
- PS-E-C6 **exploring and describing simple energy transformations;**
(2)
- PS-E-C7 **exploring and describing the uses of energy at school, home, and play.**
(1, 2, 4, 5)

BENCHMARKS 5-8

As students in Grades 5-8 extend their knowledge, what they know and are able to do includes:

A. PROPERTIES AND CHANGES OF PROPERTIES IN MATTER



- PS-M-A1 **investigating, measuring, and communicating the properties of different substances which are independent of the amount of the substance;**
(1, 2, 3, 4)

- PS-M-A2 **understanding that all matter is made up of particles called atoms and that atoms of different elements are different;**
(2, 4)



- PS-M-A3 **grouping substances according to similar properties and/or behaviors;**
(4)

- PS-M-A4 **understanding that atoms and molecules are perpetually in motion;**
(4)



- PS-M-A5 **investigating the relationships among temperature, molecular motion, phase changes, and physical properties of matter;**
(2, 3)



- PS-M-A6 **investigating chemical reactions between different substances to discover that new substances formed may have new physical properties and do have new chemical properties;**
(2, 3, 4, 5)

- PS-M-A7** understanding that during a chemical reaction in a closed system, the mass of the products is equal to that of the reactants;
(2, 3, 4)
- PS-M-A8** discovering and recording how factors such as temperature influence chemical reactions;
(2)
- PS-M-A9** identifying elements and compounds found in common foods, clothing, household materials, and automobiles.
(1, 2, 3, 4, 5)

B. MOTIONS AND FORCES

- PS-M-B1** describing and graphing the motions of objects;
(1, 2, 3)
- PS-M-B2** recognizing different forces and describing their effects (gravity, electrical, magnetic);
(1, 2)
- PS-M-B3** understanding that, when an object is not being subjected to a force, it will continue to move at a constant speed and in a straight line;
(2, 3, 4)
- PS-M-B4** describing how forces acting on an object will reinforce or cancel one another, depending upon their direction and magnitude;
(1, 2)
- PS-M-B5** understanding that unbalanced forces will cause changes in the speed or direction of an object's motion.
(2, 4)

C. TRANSFORMATIONS OF ENERGY

PS-M-C1 identifying and comparing the characteristics of different types of energy;
(2, 3, 4)

PS-M-C2 understanding the different kinds of energy transformations and the fact that energy can be neither destroyed nor created;
(2, 3, 4)

PS-M-C3 understanding that the sun is a major source of energy and that energy arrives at the Earth's surface as light with a range of wavelengths;
(2, 3, 4)

PS-M-C4 observing and describing the interactions of light and matter (reflection, refraction, absorption, transmission, scattering);
(1, 2, 3, 4)



PS-M-C5 investigating and describing the movement of heat and the effects of heat in objects and systems;
(2, 3, 4)

PS-M-C6 describing the types of energy that can be involved, converted, or released in electrical circuits;
(2, 3, 4)

PS-M-C7 understanding that energy is involved in chemical reactions;
(2, 4)



PS-M-C8 comparing the uses of different energy resources and their effects upon the environment.
(1, 2, 3, 4, 5)

BENCHMARKS 9-12

As students in Grades 9-12 extend their knowledge and abilities, what they know and are able to do includes:

A. MEASUREMENT AND SYMBOLIC REPRESENTATION

- PS-H-A1 manipulating and analyzing quantitative data using the SI system;
(2, 3, 4)
- PS-H-A2 understanding the language of chemistry (formulas, equations, symbols) and its relationship to molecules, atoms, ions, and subatomic particles.
(1, 2, 3, 4)

B. ATOMIC STRUCTURE



- PS-H-B1 describing the structure of the atom and identifying and characterizing the particles that compose it (including the structure and properties of isotopes);
(1, 2, 4)
- PS-H-B2 describing the nature and importance of radioactive isotopes and nuclear reactions (fission, fusion, radioactive decay);
(1, 2, 3, 4, 5)
- PS-H-B3 understanding that an atom's electron configuration, particularly that of the outermost electrons, determines the chemical properties of that atom.
(2, 3, 4)



C. THE STRUCTURE AND PROPERTIES OF MATTER



- PS-H-C1 distinguishing among elements, compounds, and/or mixtures;
(1, 2, 4)
- PS-H-C2 discovering the patterns of physical and chemical properties found on the periodic table of the elements;
(2, 4)

- PS-H-C3 understanding that physical properties of substances reflect the nature of interactions among its particles;
(2, 4)
- PS-H-C4 separating mixtures based upon the physical properties of their components;
(2)
- PS-H-C5 understanding that chemical bonds are formed between atoms when the outermost electrons are transferred or shared to produce ionic and covalent compounds;
(1, 2, 4)
- PS-H-C6 recognizing that carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures;
(1, 2, 3, 4)
- PS-H-C7 using the kinetic theory to describe the behavior of atoms and molecules during phase changes and to describe the behavior of matter in its different phases.
(1, 2, 4)

D. CHEMICAL REACTIONS

- PS-H-D1 observing and describing changes in matter and citing evidence of chemical change;
(1, 2, 4)
-  PS-H-D2 comparing, contrasting, and measuring the pH of acids and bases using a variety of indicators;
(1, 2, 3, 4)
- PS-H-D3 writing balanced equations to represent a variety of chemical reactions (acid/base, oxidation/reduction, etc.);
(2)
-  PS-H-D4 analyzing the factors that affect the rate and equilibrium of a chemical reaction;
(1, 2, 4)
- PS-H-D5 applying the law of conservation of matter to chemical reactions;
(1, 2, 4)



PS-H-D6 comparing and contrasting the energy changes that accompany changes in matter;
(1, 2, 4)

PS-H-D7 identifying important chemical reactions that occur in living systems, the home, industry, and the environment.
(1, 2, 3, 4, 5)

E. FORCES AND MOTION



PS-H-E1 recognizing the characteristics and relative strengths of the forces of nature (gravitational, electrical, magnetic, nuclear);
(4, 5)

PS-H-E2 understanding the relationship of displacement, time, rate of motion, and rate of change of motion; representing rate and changes of motion mathematically and graphically;
(1, 2, 3, 4)

PS-H-E3 understanding effects of forces on changes in motion as explained by Newtonian mechanics;
(1, 4)

PS-H-E4 illustrating how frame of reference affects our ability to judge motion.
(1, 2, 4)

F. ENERGY



PS-H-F1 describing and representing relationships among energy, work, power, and efficiency;
(2, 3, 4)



PS-H-F2 applying the universal law of conservation of matter, energy, and momentum, and recognizing their implications;
(2, 3, 4, 5)

G. INTERACTIONS OF ENERGY AND MATTER

PS-H-G1 giving examples of the transport of energy through wave action;
(1, 4)



PS-H-G2 analyzing the relationship and interaction of magnetic and electrical fields and the forces they produce;
(1, 2, 3, 4)



PS-H-G3 characterizing and differentiating electromagnetic and mechanical waves and their effects on objects as well as humans;
(1, 2, 4)

PS-H-G4 explaining the possible hazards of exposure to various forms and amounts of energy.
(1, 4, 5)

LIFE SCIENCE

FOCUS

As investigations of the living environment are conducted, the rationales are set to establish further observations, measurements, and classifications of the various life forms. Patterns of similarities and differences within the diversity of life establish the basis for understanding the special relationships among living things in ecosystems.

STANDARD

The students will become aware of the characteristics and life cycles of organisms and understand their relationships to each other and to their environment.

BENCHMARKS K-4

In Grades K-4, what students know and are able to do includes:

A. CHARACTERISTICS OF ORGANISMS

- LS-E-A1 identifying the needs of plants and animals, based on age-appropriate recorded observations;
(1, 2, 3, 4)
- LS-E-A2 distinguishing between living and nonliving things;
(1, 2, 3, 4)
- LS-E-A3 locating and comparing major plant and animal structures and their functions;
(1, 3)
- LS-E-A4 recognizing that there is great diversity among organisms;
(1)
- LS-E-A5 locating major human body organs and describing their functions;
(1, 4)
- LS-E-A6 recognizing the food groups necessary to maintain a healthy body.
(1, 2, 4, 5)

B. LIFE CYCLES OF ORGANISMS

- LS-E-B1** observing and describing the life cycles of some plants and animals;
(1, 3)
- LS-E-B2** observing, comparing, and grouping plants and animals according to likenesses and/or differences;
(1, 2, 4)
- LS-E-B3** observing and recording how the offspring of plants and animals are similar to their parents;
(1, 2, 3, 4)
- LS-E-B4** observing, recording, and graphing student growth over time using a variety of quantitative measures (height, weight, linear measure of feet and hands, etc.).
(1, 3)

C. ORGANISMS AND THEIR ENVIRONMENTS





- LS-E-C1** examining the habitats of plants and animals and determining how basic needs are met within each habitat;
(1, 2, 3, 4, 5)
- LS-E-C2** describing how the features of some plants and animals enable them to live in specific habitats;
(1, 2, 3, 4, 5)
- LS-E-C3** observing animals and plants and describing interaction or interdependence.
(1, 4)

BENCHMARKS 5-8


As students in Grades 5-8 extend their knowledge, what they know and are able to do includes:

A. STRUCTURE AND FUNCTION IN LIVING SYSTEMS

- LS-M-A1** describing the observable components and functions of a cell, such as the cell membrane, nucleus, and movement of molecules into and out of cells;
(1)

-  LS-M-A2 **comparing and contrasting the basic structures and functions of different plant and animal cells;**
(1, 2, 3, 4)
-  LS-M-A3 **observing and analyzing the growth and development of selected organisms, including a seed plant, an insect with complete metamorphosis, and an amphibian;**
(1, 2, 3, 4)
-  LS-M-A4 **describing the basic processes of photosynthesis and respiration and their importance to life;**
(1, 4, 5)
- LS-M-A5 **investigating human body systems and their functions (including circulatory, digestive, skeletal, respiratory);**
(1, 3, 4)
- LS-M-A6 **describing how the human body changes with age and listing factors that affect the length and quality of life;**
(1, 2, 3, 4, 5)
-  LS-M-A7 **describing communicable and noncommunicable diseases.**
(1, 2, 3, 4, 5)

B. REPRODUCTION AND HEREDITY

-  LS-M-B1 **describing the importance of body cell division (mitosis) and sex cell production (meiosis);**
(1, 4)
- LS-M-B2 **describing the role of chromosomes and genes in heredity;**
(1, 4)
- LS-M-B3 **describing how heredity allows parents to pass certain traits to offspring.**
(1, 4)

C. POPULATIONS AND ECOSYSTEMS



LS-M-C1 constructing and using classification systems based on the structure of organisms;
(1, 2, 3, 4)



LS-M-C2 modeling and interpreting food chains and food webs;
(1, 2, 3, 4)



LS-M-C3 investigating major ecosystems and recognizing physical properties and organisms within each;
(1, 2, 3, 4, 5)



LS-M-C4 explaining the interaction and interdependence of nonliving and living components within ecosystems.
(1, 2, 3, 4, 5)

D. ADAPTATIONS OF ORGANISMS

LS-M-D1 describing the importance of plant and animal adaptation, including local examples;
(1, 3, 4, 5)

LS-M-D2 explaining how some members of a species survive under changed environmental conditions.
(1, 2, 3, 4, 5)

BENCHMARKS 9-12

As students in Grades 9-12 extend their knowledge, what they know and are able to do includes:

A. THE CELL

LS-H-A1 observing cells, identifying organelles, relating structure to function, and differentiating among cell types;
(1, 2, 3, 4)

LS-H-A2 demonstrating a knowledge of cellular transport;
(1, 3, 4)



LS-H-A3 investigating cell differentiation and describing stages of embryological development in representative organisms.
(1, 2, 3, 4)

B. THE MOLECULAR BASIS OF HEREDITY

LS-H-B1 explaining the relationship among chromosomes, DNA, genes, RNA, and proteins;
(1, 3, 4)



LS-H-B2 comparing and contrasting mitosis and meiosis;
(1, 3, 4)

LS-H-B3 describing the transmission of traits from parent to offspring and the influence of environmental factors on gene expression;
(1, 2, 3, 4, 5)

LS-H-B4 exploring advances in biotechnology and identifying possible positive and negative effects.
(1, 2, 3, 4, 5)

C. BIOLOGICAL EVOLUTION

LS-H-C1 exploring experimental evidence that supports the theory of the origin of life;
(1, 3)

LS-H-C2 recognizing the evidence for evolution;
(1, 3, 4)

LS-H-C3 discussing the patterns, mechanisms, and rate of evolution;
(1, 3, 4)



LS-H-C4 classifying organisms;
(1, 2, 3, 4)

LS-H-C5 distinguishing among the kingdoms;
(1, 3, 4)



LS-H-C6 **comparing and contrasting life cycles of organisms;**
(1, 2, 3, 4)



LS-H-C7 **comparing viruses to cells.**
(1, 2, 3, 4)

D. INTERDEPENDENCE OF ORGANISMS



LS-H-D1 **illustrating the biogeochemical cycles and explaining their importance;**
(1, 2, 3, 4, 5)

LS-H-D2 **describing trophic levels and energy flows;**
(1, 3, 4, 5)

LS-H-D3 **investigating population dynamics;**
(2, 3, 4, 5)

LS-H-D4 **exploring how humans have impacted ecosystems and the need for societies to plan for the future.**
(1, 2, 4, 5)

E. MATTER, ENERGY, AND ORGANIZATION OF LIVING SYSTEMS



LS-H-E1 **comparing and contrasting photosynthesis and cellular respiration; emphasizing their relationships;**
(1, 2, 3, 4)

LS-H-E2 **recognizing the importance of the ATP cycle in energy usage within the cell;**
(1, 2, 3, 4)

LS-H-E3 **differentiating among levels of biological organization.**
(1, 4)

F. SYSTEMS AND THE BEHAVIOR OF ORGANISMS

- LS-H-F1** identifying the structure and functions of organ systems;
(1, 3, 4)
- LS-H-F2** identifying mechanisms involved in homeostasis;
(1, 3, 4)
- LS-H-F3** recognizing that behavior is the response of an organism to internal changes and/or external stimuli;
(1, 3, 4)
- LS-H-F4** recognizing that behavior patterns have adaptive value.
(3, 4)

G. PERSONAL AND COMMUNITY HEALTH

- LS-H-G1** relating fitness and health to longevity;
(1, 3, 4, 5)
- LS-H-G2** contrasting how organisms cause disease;
(1, 3, 4, 5)
- LS-H-G3** explaining the role of the immune system in fighting disease;
(1, 3, 4, 5)
- LS-H-G4** exploring current research on the major diseases with regard to cause, symptoms, treatment, prevention, and cure;
(1, 3, 4, 5)
- LS-H-G5** researching technology used in prevention, diagnosis, and treatment of diseases/disorders.
(1, 3, 4, 5)

EARTH AND SPACE SCIENCE

FOCUS

In order to develop a basic understanding of our world, it is essential for students to reflect upon the structure, order, and origin of the universe. This understanding occurs gradually over time as students observe, investigate, model, describe, and find patterns in a changing world. As humans modify their surroundings, they must reflect upon the consequences that these changes will bring. Scientific knowledge about environmental forces and resources will provide a rich topic for critical thinking by students to analyze the effects of their choices on the world.

STANDARD

The students will develop an understanding of the properties of earth materials, the structure of the Earth system, the Earth's history, and the Earth's place in the universe.

BENCHMARKS K-4

In Grades K-4, what students know and are able to do includes:

A. PROPERTIES OF EARTH MATERIALS

- ESS-E-A1** understanding that earth materials are rocks, minerals, and soils;
(1)
- ESS-E-A2** understanding that approximately three-fourths of the Earth's surface is covered with water and how this condition affects weather patterns and climates;
(1)
- ESS-E-A3** investigating, observing, and describing how water changes from one form to another and interacts with the atmosphere;
(2, 4)
- ESS-E-A4** investigating, observing, measuring, and describing changes in daily weather patterns and phenomena;

(2, 4)

ESS-E-A5 observing and communicating that rocks are composed of various substances;
(1)

ESS-E-A6 observing and describing variations in soil;
(1)

ESS-E-A7 investigating fossils and describing how they provide evidence about plants and animals that lived long ago and the environment in which they lived.
(1, 2, 4)

B. OBJECTS IN THE SKY

ESS-E-B1 observing and describing the characteristics of objects in the sky;
(1)

ESS-E-B2 demonstrating how the relationship of the Earth, moon, and sun causes eclipses and moon phases;
(2, 3, 4)

ESS-E-B3 observing and recording the changing appearances and positions of the moon in the sky at night and determining the monthly pattern of lunar change;
(1, 2, 3, 4)

ESS-E-B4 modeling changes that occur because of the rotation of the Earth (alternation of night and day) and the revolution of the Earth around the sun;
(1, 2, 3, 4)

ESS-E-B5 understanding that the sun, a star, is a source of heat and light energy and identifying its effects upon the Earth;
(1, 2, 3, 4)

ESS-E-B6 understanding that knowledge of the Earth as well as of the universe is gained through space exploration.
(1)

BENCHMARKS 5-8

WARNING: BENCHMARKS 9-12 NEED TO BE ADDRESSED IF EARTH SCIENCE IS NOT OFFERED AT THE HIGH SCHOOL LEVEL.

As students in Grades 5-8 extend their knowledge, what they know and are able to do includes:

A. STRUCTURE OF THE EARTH

ESS-M-A1 understanding that the Earth is layered by density with an inner and outer core, a mantle, and a thin outer crust;
(1)

ESS-M-A2 understanding that the Earth's crust and solid upper mantle are dividing plates that move in response to convection currents (energy transfers) in the mantle;
(1)



ESS-M-A3 investigating the characteristics of earthquakes and volcanos and identifying zones where they may occur;
(2, 3, 4)

ESS-M-A4 investigating how soils are formed from weathered rock and decomposed organic material;
(2, 3, 4)

ESS-M-A5 identifying the characteristics and uses of minerals and rocks and recognizing that rocks are mixtures of minerals;
(2, 3, 4)



ESS-M-A6 explaining the processes involved in the rock cycle;
(1, 4)

ESS-M-A7 modeling how landforms result from the interaction of constructive and destructive forces;
(1, 2, 3, 4)

ESS-M-A8 identifying the man-made and natural causes of coastal erosion and the steps taken to combat it;
(1, 2, 3, 4, 5)



ESS-M-A9 **compare and contrast topographic features of the ocean floor to those formed above sea level;**
(2, 3, 4)



ESS-M-A10 **explaining (illustrating) how water circulates -- on and through the crust, in the oceans, and in the atmosphere -- in the water cycle;**
(1, 4)

ESS-M-A11 **understanding that the atmosphere interacts with the hydrosphere to affect weather and climate conditions;**
(1, 4)

ESS-M-A12 **predicting weather patterns through use of a weather map.**
(1, 2, 3, 4, 5)

B. EARTH HISTORY

ESS-M-B1 **investigating how fossils show the development of life over time;**
(2, 3, 4)

ESS-M-B2 **devising a model that demonstrates supporting evidence that the Earth has existed for a vast period of time;**
(1, 2, 3, 4)

ESS-M-B3 **understanding that earth processes such as erosion and weathering affect the Earth today and are similar to those which occurred in the past.**
(1, 2, 3, 4)

C. EARTH IN THE SOLAR SYSTEM

ESS-M-C1 **identifying the characteristics of the sun and other stars;**
(1, 2, 3, 4)



ESS-M-C2 **comparing and contrasting the celestial bodies in our solar system;**
(2, 4)



ESS-M-C3 **investigating the force of gravity and the ways gravity governs motion in the solar system and objects on Earth;**
(2, 3, 4)

- ESS-M-C4 modeling the motions of the Earth-moon-sun system to explain day and night, a year, eclipses, moon phases, and tides;
(1, 2, 3, 4)
- ESS-M-C5 modeling the position of the Earth in relationship to other objects in the solar system;
(1, 2, 3, 4)
- ESS-M-C6 modeling and describing how radiant energy from the sun affects phenomena on the Earth's surface, such as winds, ocean currents, and the water cycle;
(1, 2, 3, 4)
- ESS-M-C7 modeling and explaining how seasons result from variations in amount of the sun's energy hitting the surface due to the tilt of Earth's rotation on its axis and the length of the day;
(1, 2, 3, 4)
- ESS-M-C8 understanding that space exploration is an active area of scientific and technological research and development.
(1, 5)

BENCHMARKS 9-12

As students in Grades 9-12 extend their knowledge, what they know and are able to do includes:

A. ENERGY IN THE EARTH SYSTEM

- ESS-H-A1 investigating the methods of energy transfer and identifying the sun as the major source of energy for most of the Earth's systems;
(1, 3, 4)
-  ESS-H-A2 modeling the seasonal changes in the relative position and appearance of the sun and inferring the consequences with respect to the Earth's temperature;
(1, 2, 3, 4)
-  ESS-H-A3 explaining fission and fusion in relation to the Earth's internal and external heat sources;
(1, 3, 4)

- ESS-H-A4** explaining how decay of radioactive isotopes and the gravitational energy from the Earth's original formation generates the Earth's internal heat;
(1, 3, 4)
- ESS-H-A5** demonstrating how the sun's radiant energy causes convection currents within the atmosphere and the oceans;
(1, 2, 3, 4)
- ESS-H-A6** describing the energy transfer from the sun to the Earth and its atmosphere as it relates to the development of weather and climate patterns;
(1, 2, 3, 4)
- ESS-H-A7** modeling the transfer of the Earth's internal heat by way of convection currents in the mantle which powers the movement of the lithospheric plates.
(1, 2, 3, 4)

B. GEOCHEMICAL CYCLES



- ESS-H-B1** illustrating how stable chemical atoms or elements are recycled through the solid earth, oceans, atmosphere, and organisms;
(1, 2, 3, 4)
- ESS-H-B2** demonstrating Earth's internal and external energy sources as forces in moving chemical atoms or elements.
(1, 2, 3, 4)

C. THE ORIGIN AND EVOLUTION OF THE EARTH SYSTEM

- ESS-H-C1** explaining the formation of the solar system from a nebular cloud of dust and gas;
(1, 2, 3, 4)
- ESS-H-C2** estimating the age of the Earth by using dating techniques;
(1, 2, 3, 4)
- ESS-H-C3** communicating the geologic development of Louisiana;
(1, 2, 3, 4)

ESS-H-C4 examining fossil evidence as it relates to the evolution of life and the resulting changes in the amount of oxygen in the atmosphere;
(1, 2, 3, 4)

ESS-H-C5 explaining that natural processes and changes in the Earth system may take place in a matter of seconds or develop over billions of years.
(1, 2, 3, 4)

D. THE ORIGIN AND EVOLUTION OF THE UNIVERSE

ESS-H-D1 identifying scientific evidence that supports the latest theory of the age and origin of the universe;
(1, 2, 3, 4)

ESS-H-D2 describing the organization of the known universe;
(1, 3, 4)



ESS-H-D3 comparing and contrasting the sun with other stars;
(1, 4)

ESS-H-D4 identifying the elements found in the sun and other stars by investigating the spectra;
(1, 2, 3, 4)

ESS-H-D5 describing the role of hydrogen in the formation of all the natural elements;
(1, 4)

ESS-H-D6 demonstrating the laws of motion for orbiting bodies;
(1, 3, 4)

ESS-H-D7 describe the impact of technology on the study of the Earth, the solar system, and the universe.
(1, 2, 3, 4, 5)

SCIENCE AND THE ENVIRONMENT

FOCUS

Environmental education is a process aimed at the development of a literate citizenry which is aware of and shows concern for the total environment and its associated problems. This goal will be met by developing the knowledge, attitudes, motivation, commitment, and skills to work individually and collectively toward the solutions of current problems and the prevention of new ones.

STANDARD

In learning environmental science, students will develop an appreciation of the natural environment, learn the importance of environmental quality, and acquire a sense of stewardship. As consumers and citizens, they will be able to recognize how our personal, professional, and political actions affect the natural world.

BENCHMARKS K-4

In Grades K-4, what students know and are able to do includes:

- SE-E-A1 understanding that an “ecosystem” is made of living and non-living components;
(1, 3, 4)
- SE-E-A2 understanding the components of a food chain;
(1, 3, 4)
- SE-E-A3 identifying ways in which humans have altered their environment, both in positive and negative ways, either for themselves or for other living things;
(1, 2, 3, 4, 5)
- SE-E-A4 understanding that the original sources of all material goods are natural resources and that the conserving and recycling of natural resources is a form of stewardship;
(1, 2, 3, 4, 5)

- SE-E-A5** understanding that most plant and animal species are threatened or endangered today due to habitat loss or change.
(1, 2, 4)

BENCHMARKS 5-8

As students in Grades 5-8 extend their knowledge, what they know and are able to do includes:



- SE-M-A1** demonstrating knowledge that an ecosystem includes living and nonliving factors and that humans are an integral part of ecosystems;
(1, 3, 4, 5)

- SE-M-A2** demonstrating an understanding of how carrying capacity and limiting factors affect plant and animal populations;
(1, 2, 3, 4, 5)

- SE-M-A3** defining the concept of pollutant and describing the effects of various pollutants on ecosystems;
(1, 2, 3, 4, 5)



- SE-M-A4** understanding that human actions can create risks and consequences in the environment;
(1, 2, 3, 4, 5)



- SE-M-A5** tracing the flow of energy through an ecosystem and demonstrating a knowledge of the roles of producers, consumers, and decomposers in the ecosystem;
(1, 2, 3, 4, 5)



- SE-E-A6** distinguishing between renewable and nonrenewable resources and understanding that nonrenewable natural resources are not replenished through the natural cycles and thus are strictly limited in quantity;
(1, 2, 3, 4, 5)



- SE-M-A7** demonstrating knowledge of the natural cycles, such as the carbon cycle, nitrogen cycle, water cycle, and oxygen cycle;
(1, 2, 4)

SE-M-A8 investigating and analyzing how technology affects the physical, chemical, and biological factors in an ecosystem;
(1, 2, 3, 4, 5)



SE-M-A9 demonstrating relationships of characteristics of soil types to agricultural practices and productivity;
(1, 2, 3, 4, 5)

SE-M-A10 identifying types of soil erosion and preventive measures.
(1, 2, 3, 4, 5)

BENCHMARKS 9-12

As students in Grades 9-12 extend their knowledge, what they know and are able to do includes:

A. ECOLOGICAL SYSTEMS AND INTERACTIONS

SE-H-A1 demonstrating an understanding of the functions of Earth's major ecological systems;
(1, 2, 3, 4)



SE-H-A2 investigating the flow of energy in ecological systems;
(1, 2, 3, 4)



SE-H-A3 describing how habitat, carrying capacity, and limiting factors influence plant and animal populations (including humans);
(1, 3, 4, 5)

SE-H-A4 understanding that change is a fundamental characteristic of every ecosystem and that ecosystems have varying capacities for change and recovery;
(1, 2, 3, 4, 5)

SE-H-A5 describing the dynamic interactions between divisions of the biosphere;
(1, 3, 4)



SE-H-A6 describing and explaining the Earth's biochemical and geochemical cycles and their relationship to ecosystem stability;
(1, 2, 4)



SE-H-A7 **comparing and contrasting the dynamic interaction within the biosphere;**
(1, 2, 4)

SE-H-A8 **analyzing evidence that plant and animal species have evolved physical, biochemical, and/or behavioral adaptations to their environments;**
(1, 2, 3, 4, 5)

SE-H-A9 **demonstrating an understanding of influencing factors of biodiversity;**
(1, 3, 4, 5)

SE-H-A10 **explaining that all species represent a vital link in a complex web of interaction;**
(1, 3, 4, 5)



SE-H-A11 **understanding how pollutants can affect living systems.**
(1, 2, 3, 4, 5)

B. RESOURCES AND RESOURCE MANAGEMENT

SE-H-B1 **explaining the relationships between renewable and nonrenewable resources;**
(1, 3, 4)



SE-H-B2 **comparing and contrasting conserving and preserving resources;**
(1, 3, 4)

SE-H-B3 **recognizing that population size and geographic and economic factors result in the inequitable distribution of the Earth's resources;**
(1, 2, 3, 4, 5)



SE-H-B4 **comparing and contrasting long and short-term consequences of resource management;**
(1, 2, 3, 4, 5)

SE-H-B5 **analyzing resource management;**
(1, 2, 3, 4, 5)

SE-H-B6 recognizing that sustainable development is a process of change in which resource use, investment direction, technological development, and institutional change meet society's present as well as future needs.
(1, 2, 3, 4, 5)

C. ENVIRONMENTAL AWARENESS AND PROTECTION

SE-H-C1 evaluating the dynamic interaction of land, water, and air and its relationship to living things in maintaining a healthy environment;
(1, 2, 3, 4, 5)



SE-H-C2 evaluating the relationships between quality of life and environmental quality;
(1, 2, 3, 4, 5)

SE-H-C3 investigating and communicating how environmental policy is formed by the interaction of social, economic, technological, and political considerations;
(1, 2, 3, 4, 5)

SE-H-C4 demonstrating that environmental decisions include analyses that incorporate ecological, health, social, and economic factors;
(1, 2, 3, 4, 5)

SE-H-C5 analyzing how public support affects the creation and enforcement of environmental laws and regulations.
(1, 2, 3, 4, 5)

D. PERSONAL CHOICES AND RESPONSIBLE ACTIONS

SE-H-D1 demonstrating the effects of personal choices and actions on the natural environment;
(1, 2, 3, 4, 5)



SE-H-D2 analyzing how individuals are capable of reducing and reversing their impact on the environment through thinking, planning, education, collaboration, and action;
(1, 2, 3, 4, 5)

- SE-H-D3** demonstrating that the most important factor in prevention and control of pollution is education;
(1, 2, 3, 4, 5)
- SE-H-D4** demonstrating a knowledge that environmental issues should be a local and global concern;
(1, 2, 3, 4, 5)
- SE-H-D5** recognizing that the development of accountability toward the environment is essential for sustainability;
(1, 2, 3, 4, 5)
- SE-H-D6** developing an awareness of personal responsibility as stewards of the local and global environment.
(1, 2, 3, 4, 5)

SECTION V: GLOSSARY

<u>ability</u>	Power to perform, whether physical, moral, intellectual, or legal. Skill or competence.
<u>analyzing</u>	To separate mentally all parts (of a whole) as to reveal their relation to it and to one another.
<u>assessment</u>	The systematic, multistep process involving the collection and interpretation of educational data.
<u>benchmark</u>	Specify what students should know and be able to do.
<u>content standards</u>	Broad statement of process and/or content that are used as a reference to develop curriculum and assess student progress.
<u>conserving</u>	The use of natural resources in a way that assures their continuing availability to future generations; the intelligent use of natural resources for long-term benefits.
<u>consumer</u>	Any organism that feeds from another.
<u>curriculum</u>	A document (usually developed at the local level) which aides teachers in planning instruction. The way content is delivered. It includes the structure, organization, balance, and presentation of the content in the classroom. Note: This definition includes instructional materials, and the teacher's strategies, behaviors, and assessment.
<u>demonstrate</u>	To prove by reasoning, as by deduction; to establish as true.
<u>describing</u>	To represent by words; to give an account of.
<u>energy</u>	The capacity to perform work, or the potential for power and activity.
<u>energy resources</u>	Origins of natural energy (coal, oil, gas, etc.).

<u>experimentation</u>	Practice by experiment. A trial made to confirm or disprove something doubtful; an operation made to discover some unknown principle or effect.
<u>framework</u>	A document (usually developed at the state level) which provides a vision of how the national standards can best be implemented, given the characteristics of that particular state.
<u>inquiry</u>	A seeking for information by asking questions; interrogation; a question or questioning.
<u>instructional materials</u>	The physical components of the curriculum, including textbooks, software, kits, and teachers' guides.
<u>knowing</u>	Informed; intelligent. Having or displaying discernment.
<u>preserving</u>	Protection which emphasizes nonconsumptive values and uses, including no direct use by humans, contrasted with conservation which emphasizes both consumptive and nonconsumptive values and uses.
<u>producer</u>	Any organism that is capable of making its own food.
<u>recognize</u>	To avow knowledge of; to admit with formal acknowledgment.
<u>scientific investigation</u>	To follow up or make research by patient inquiry and observation and examination of the facts.
<u>skill</u>	A particular art or science; now a developed or acquired ability. The ability to use one's knowledge effectively; technically proficient.
<u>understanding</u>	Power to understand; capability of comprehending and judging; the rational powers taken collectively.

SECTION VI: REFERENCES

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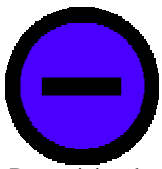


Science Examples



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Determining the Mass of an Electron (m_e)

J.J. Thomson
1856-1940

Cathode ray
experiment

Won the Nobel
Prize in Physics
in 1906

Showed that
cathode rays
were deflected
in an electric
field

Beam was
attracted to the
positive plate
and repelled by
the negative
plate

Since opposites
attract

Conclusion: the
cathode ray was
composed of
negatively
charged particles

Cathode rays
are also
deflected in
magnetic fields

Particles were the same
regardless of the
materials used to make
the electrodes or the type
of gas used in the tube

Named them
electrons

$$e/m = E/B^2r$$

E, B, and r are
known
quantities

$$e/m = 1.76 \times 10^{11} \text{ C/kg}$$

Conclusion: the
negative particles
were common to
all kinds of atoms

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

Robert A. Millikan
1868-1953

Oil drop
experiment

Tiny droplets of
mineral oil

Gravitational
force caused the
droplets to fall
between two
parallel plates

Millikan adjusted the
electric field until
exactly balanced with
the gravitational force

Measured mass
of droplet in
absence of
electric field

Each carried an
electric charge

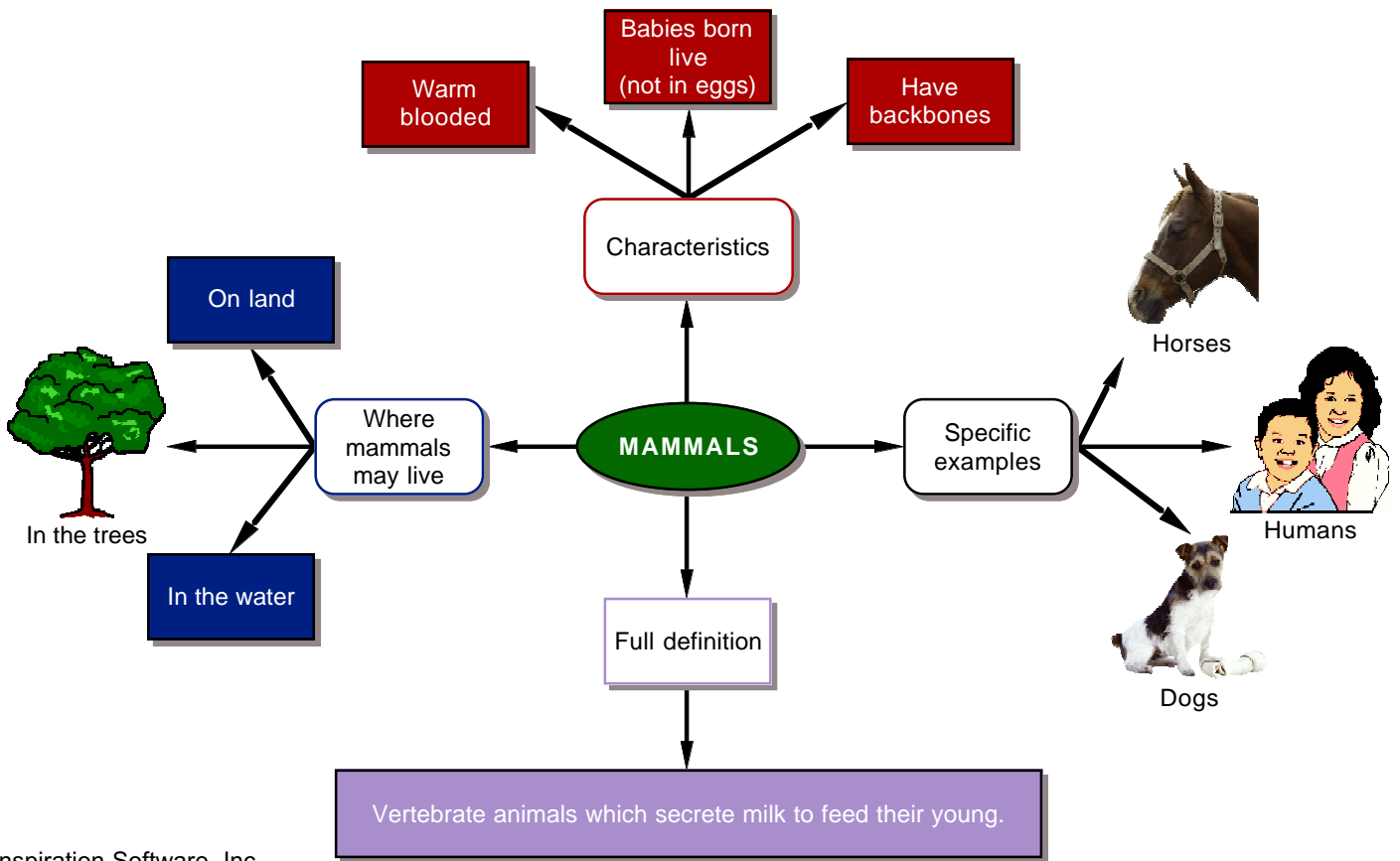
Oil droplets
became
suspended
between the two
plates

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$qE = mg$$

$$q = mg/E$$

m, g, and E are
known
quantities



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SOUND

was first broken by

General Chuck Yeager

in a



named

"Glamorous Glennis"

after

Yeager's wife

Bell X-1

on

October 17, 1947

at

Muroc Dry Lake Beds, CA

now known as

Edwards AFB

whose

speed v

=

wave length

X

frequency f

which is called the

Wave Equation

is a

longitudinal wave

can travel in



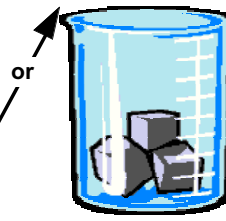
Gases

such as

air

whose

speed



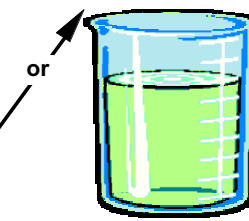
Solids

such as

steel

which travels

5000 m/s



Liquids

such as

water

which travels

1482 m/s @ 20° C

density

and

temperature

which vary with

altitude

which is a function of

frequencies

of

20-20,000 Hz

the range of

human hearing

15-50,000 Hz

the range of

canine hearing

1000-150,000 Hz

the range of

bat hearing

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