KANSAS

Science Education Standards

Adopted February 2007
Revised August 2007

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Dedication

The writing committee dedicates the *Kansas Science Education Standards* to all Kansans. With this document, we pass on the legacy of our own teachers, who helped us understand that lifelong learners of science live more productive, responsible, and fulfilling lives. We share this legacy with our students, active participants in the future of Kansas.

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Mission Statement

Kansas science education contributes to the preparation of all students as lifelong learners who can use science to make reasoned decisions that contribute to their local, state, national and international communities.

Vision Statement

Science education in Kansas is intended to help students to develop the understandings and intellectual abilities they need to lead personal fulfilling lives and to equip them to participate thoughtfully with fellow citizens in building and protecting an open, equitable, and vital society. The educational system must prepare the citizens of Kansas to meet the challenges of the 21st century and to be competitive in a world that has an increasingly level playing field. With this in mind, the intent for the *Kansas Science Education Standards* can be expressed in a single phrase that embodies both excellence and equity: High quality science standards for all students. These standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and/or motivation in the sciences.

Science education in Kansas strongly emphasizes the skill of scientific inquiry as an essential component of scientific literacy. These standards are written to make, "Science as inquiry ... basic to science education and a controlling principle in the ultimate organization and selection of students' activities" (NRC, 1996). The National Science Education Standard on Inquiry clearly state actions students participate in as a part of an inquiry-based science education:

> "Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments." (NRC, 1996, p. 105)

These standards are built on the premise that science is an active process; something that students and adults actively do, not something that is only demonstrated for them. This active engagement allows teachers to operate as a mediator, guide, provocateur, friend and co-learner with their students. Knowledge gained in the context of scientific inquiry provides fertile ground where students can transfer their knowledge to multiple contexts. As a result of the experiences outlined in these standards students have a deep understanding of science knowledge and are empowered to add to the growing body of scientific knowledge.

Purpose of this Document

These standards, benchmarks, indicators, and examples are designed to assist Kansas educators in selecting and developing local curricula, carrying out instruction, and assessing students' progress. They will also serve as the foundation for the development of state assessments in science. Finally, these standards, benchmarks, indicators, and examples represent high, yet reasonable expectations for all students.

The *Kansas Science Education Standards*:

- Provide criteria Kansas educators and stakeholders can use to judge whether particular actions will serve the vision of a scientifically literate society.

- Bring coordination, consistency, and coherence to the improvement of science education.

- Advocate that science education must be developmentally appropriate and reflect a systemic, progressive approach throughout the elementary, middle, and high school years. (See Implementation, p. ix)

These standards should not be viewed as a state curriculum or instructional strategy. The content embodied in these standards can be organized and presented with many different emphases and perspectives in local district curricula. (See Implementation, p. ix)

Development of the Kansas Science Education Standards

The original *Kansas Curricular Standards for Science* was drafted in 1992, approved by the Kansas State Board of Education in 1993, and up-dated in 1995. Although all of this work occurred prior to the release of the *National Science Education Standards* in 1996, the original Kansas standards reflect early work on the national standards.

At the August, 1997 meeting of the Kansas State Board of Education, the Board directed that academic standards committees composed of stakeholders from throughout Kansas should be convened in each curriculum area defined by Kansas law (reading, writing, mathematics, science, and social studies). The 1998-2001 science standards committee was able to build upon and benefited from a great deal of prior work done on a national level; the *National Science Education Standards* published by the National Research Council; *Benchmarks for Science Literacy* from Project 2061 of the American Association for the Advancement of Science (AAAS); and *Pathways to the Science Standards*, published by the National Science Teachers Association (NSTA). This allowed the foundation for the *Kansas Science Education Standards (2001)* to be based on research and on the work of over 18,000 scientists, science educators, teachers, school administrators and parents across the country that produced national standards as well as the school district teams and thousands of individuals who contributed to the benchmarks. *Kansas Curricular Standards for Science* was approved by the Kansas State Board of Education on February 14, 2001.

As part of the federal reauthorized 2002 Elementary and Secondary Education Act (ESEA), known as “No Child Left Behind’ and as part of the state’s requirement to review curriculum standard every three years, at the April, 2004 meeting of the Kansas State Board of Education, the Board directed that academic standards committees should be convened and charge to:

- Review the current science standards as well as national and other state standards in light of what students should know and be able to do by each grade level assessed.
- Review the format of the curricular standards to ensure they are understandable and useable.
- Determine the level of specificity needed at each level – standards, benchmark or indicator – in terms of the content to be learned and complexity of skill assessed on the state assessments.
- Ensure standards are written in specific and measurable terms to provide greater instructional clarity for at least each grade level assessed.
- Recommend essential indicators to be assessed in the state assessment program, including additional indicators local districts may use to enrich and enhance their curriculum.
- Review the modified and extended standards to include in the revised standards document.
- Submit first draft of the revised science standard to the State Board by December, 2004.

These standards are based on the *National Science Education Standards* (NRC, 1996). The process of developing these standards has been advised by Kansas Educators (November 2004 Field Review), Kansas Citizens (February 2005 Public Hearings), and the external review of the standards conducted by McREL (Mid-continent Research and Education Leadership). In developing the 2006 Kansas Science Education Standards, portions of documents developed by the National Research Council, AAAS, and NSTA have been used with permission.

Organization of the Kansas Science Education Standards

Each standard in the main body of the document contains a series of benchmarks, which describe what students should know and be able to do at the end of a certain point in their education (i.e., grades 2, 4, 7, and 12). Each benchmark contains a series of indicators, which identify what it means for students to meet a benchmark. Indicators are frequently followed by examples, which are specific, concrete ideas or illustrations of the standards writers' intent.

Standards

There are seven standards for science. These standards are general statements of what students should know, understand, and be able to do in the natural sciences over the course of their K-12 education. The seven standards are interwoven ideas, not separate entities; thus, they should be taught as interwoven ideas, not as separate entities. These standards are clustered for grade levels K-2, 3-4, 5-7, and 8-12.

1. Science as Inquiry
2. Physical Science (Physics and Chemistry)
3. Life Science
4. Earth and Space Science
5. Science and Technology
6. Science in Personal and Environmental Perspectives
7. History and Nature of Science

Benchmarks

Benchmarks are specific statements of what students should know and be able to do at a specified point in their schooling. Benchmarks are used to measure students' progress toward meeting a standard. In these standards, benchmarks are defined for grades 2, 4, 7, and 12.

Indicators

Indicators are statements of the knowledge or skills which students demonstrate in order to meet a benchmark. Indicators are critical to understanding the standards and benchmarks and are to be met by all students. The indicators listed under each benchmark are not listed in priority order, nor do the indicators include all potential topics related to the benchmarks. Moreover, the list of examples with each indicator should be considered as representative but not as comprehensive or all-inclusive.

Instructional Examples, Teacher Notes, and Additional Specificity

To assist in the implementation of the standards, additional information is added to indicators in the form of Instructional Examples, Teacher Notes, and Additional Specificity. Instructional Examples offers an activity or a specific concrete instance of an idea of what is called for by an indicator. Teacher Notes clarify vocabulary. Information labeled Additional Specificity provides an illustration of the meaning or intent of an indicator. Like the indicators themselves, these forms of information are considered to be representative but not comprehensive or all-inclusive.

Linking the Standards to the Kansas Science Assessment

Assessed indicators are marked with a delta. The delta with a numbered indicator means that this indicator has been designated for emphasis on the new Kansas Science Assessments.

- An indicator with a delta ▲ in the Grades K-4 Standards will be assessed at Grade 4.
- An indicator with a delta ▲in the Grades 5-7 Standards will be assessed at Grade 7.
- An indicator with a delta ▲ in the Grades 8-12 Standards will be assessed at a high school grade by the Kansas State Assessment. The marked indicators are aligned with the ACT science subtest and may be helpful for students who choose to take this assessment.

Implementation of the Kansas Science Education Standards:

Actions by Kansas school districts to implement the Kansas Science Education Standards (KSES) should include:

1. Use the Kansas Science Education Standards as a framework for local curriculum, including Extended Standards for special needs students. KSES provides a framework for building local curriculum. Local curriculum, developed from these standards, determines what is taught/learned in science. Local curriculum also provides local district with a guide for selecting instructional resources.

2. Distribute complete sets of Kansas Science Education Standards to all K-12 science teachers and K-12 administrators. Make all grade levels aware of the assessed indicators, and include all the KSES standards in local district K-12 science curriculum. Local districts are advised to insure that all of the KSES are included in local curriculum and that assessed indicators are not the entire focus of the use of the standards document.

3. Match each KSES indicator with the local grade level that includes the indicator in local curriculum**.** Determine what local district action is needed if there are KSES standards/indicators that are not addressed in local curriculum. (Note: Once approved by the KSBE, these standards will include in the Appendix a version of the standards that show a sample grade-by grade breakdown of the grade span indicators.)

4. Develop local curriculum that integrates science learning with concepts and skills of other curriculum areas, especially math.

5. Classroom teachers select developmentally appropriate instructional strategies to develop the understandings and abilities described in KSES. The importance of inquiry does not imply that all teachers should pursue a single approach to teaching science.

6. Develop local assessments that support the Kansas Science Education Standards and extend beyond learning the measured Kansas Science Assessments.

7. Provide ongoing, research-based professional development for K-12 science teachers (all grade levels, not just assessed grade levels) to assure that all students have a highly qualified science teacher. Science teachers need professional development time and support for a creative teaching and learning environment described by KSES as lab-based, inquiry science.

8. Provide the resources needed for science learning: highly qualified science teachers, adequate class time, a rich array of learning materials, equipped and safe science classrooms, and the resources of the communities surrounding the schools.

9. Focus on K-12 student learning in science, while meeting the science learning requirements of federal “No Child Left Behind” legislation (NCLB) and Quality Performance Accreditation (QPA). Inform all science teachers of Kansas State Department of Education (KSDE) assessment schedules and procedures. No Child Left Behind (2002 federal legislation) requires states to assess annually in science, beginning in 2007, at designated grade levels. (See “Linking the Standards to the Kansas Science Assessment,” p. 4) NCLB also requires school districts to provide highly qualified science teachers for all students by 2005.

Quality Performance Accreditation is the process for accrediting Kansas schools. Each school should include science student achievement targets in the School Improvement Plan.

10. These standards provide a framework for local curriculum for science knowledge and skills for all students to attain. For students going beyond the expectations for all students with their high school science education, taking advanced courses such as Anatomy and Physiology or Advanced Placement courses, these standards provide a conceptual framework upon which to build advanced curriculum.

11. Provide information about the Kansas Science Education Standards to all community members who support science learning, including parents.

12. Participate in teacher development workshops on Kansas Science Education Standards implementation provided by KSDE.

Teaching With Tolerance and Respect

Science studies natural phenomena by formulating explanations that can be tested against the natural world. Some scientific concepts and theories (e.g., blood transfusion, human sexuality, nervous system role in consciousness, cosmological and biological evolution, etc.) may differ from the teachings of a student's religious community or their cultural beliefs. Compelling student belief is inconsistent with the goal of education. Nothing in science or in any other field of knowledge shall be taught as absolute knowledge. A teacher is an important role model for demonstrating respect, sensitivity, and civility. Science teachers should not ridicule, belittle or embarrass a student for expressing an alternative view or belief. Teachers have the opportunity to display and demand tolerance and respect for the diverse ideas, skills, and experiences of all students.

Teaching in the Outdoors

Many Kansans now live in environments where nature seems irrelevant, except as entertainment, and the economy dominates our priorities. Current economic trends are based less on production and more on consumption; so often nature and nature's services are valued less. In some respects, humans at the dawn of the species probably knew more about the natural world than does the average Kansas citizen of today. The rise of civilization and more recent increase in urbanization has been paralleled by decreasing personal contact with the natural world. Despite the fact that we are a part of a highly interconnected web of life, the separation of so many people from direct contact with nature has had enormous consequences. The accumulating research reveals the necessity of contact with nature for healthy child development. Varied experiences in the outdoors make natural processes less abstract and are critical to developing scientific literacy. Two authors who describe the importance of children, youth and young adults having direct experience in the out-of-doors are Gary Paul Nabhan and Stephen Trimble in *The Geography of Childhood: Why Children Need Wild Places* (Beacon Press, 1994) and Richard Louv, in his recent book, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder* (Algonquin Press, 2005).

Nature of Science

Science is a human activity of systematically seeking natural explanations for what we observe in the world around us. Throughout history people from many cultures have used the methods of science to contribute to scientific knowledge and technological innovations, making science a worldwide enterprise. Scientists test explanations against the natural world, logically integrating observations and tested hypotheses with accepted explanations to gradually build more reliable and accurate understandings of nature. Scientific explanations must be testable and repeatable, and findings must be confirmed through additional observation and experimentation. As it is practiced in the late 20th and early 21st century, science is restricted to explaining only the natural world, using only natural cause. This is because science currently has no tools to test explanations using non-natural (such as supernatural) causes.

It is important to note that science cannot answer all questions. Some questions are simply beyond the parameters of science. Among the conditions that help define the boundaries of scientific explanations are the following:

- *Scientific explanations are based on empirical observations or experiments*. The appeal to authority as a valid explanation does not meet the requirements of science. Observations are based on sense experiences or on an extension of the senses through technology.
- *Scientific explanations assume cause-effect relationships*. Much of science is directed toward determining causal relationships and developing explanations for interactions and linkages between objects, organisms, and events. Distinctions among causality, correlation, coincidence, and contingency separate science from pseudoscience.
- *Scientific explanations are tentative.* Explanations can and do change. There are no scientific truths in an absolute sense.
- *Scientific explanations are historical.* Past explanations are the basis for contemporary explanations, and those, in turn, are the basis for future explanations.
- *Scientific explanations are probabilistic*. The statistical view of nature is evident implicitly or explicitly when stating scientific predictions of phenomena or explaining the likelihood of events in actual situations.
- *Scientific explanations are limited*. Scientific explanations sometimes are limited by technology, for example, the resolving power of microscopes and telescopes. New technologies can result in new fields of inquiry or extend current areas of study. The interactions between technology and advances in molecular biology and the role of technology in planetary explorations serve as examples.
- *Scientific explanations are made public.* Scientists make presentations at scientific meetings or publish in professional journals, making knowledge public and available to other scientists.

Hypothesis, law, and theory are frequently misunderstood terms used in science. A hypothesis is a testable statement about the natural world that can be used to design experiments and to build more complex inferences and explanations. A law is a descriptive generalization based on repeated observations. A theory is a well-substantiated explanation of the natural world that incorporates observations, inferences, laws, well-tested hypotheses and experimental findings to explain a specific aspect of the natural world. Theories drive research because they draw attention to areas where data or understandings are incomplete, suggesting additional directions for research.

Because all scientific explanations depend on observational and experimental confirmation, all scientific knowledge is, in principle, subject to change as additional evidence becomes available and/or as new technologies extends our abilities to explore. This open-endedness of science is its greatest strength, and allows for constant refining and improvement of explanations. Although all scientific knowledge is in principle tentative, science has a high degree of confidence in explanations that have been repeatedly tested and shown to be valid. The effect of these criteria is to ensure that scientific explanations about the world can be modified or abandoned in favor of new explanations if empirical evidence so warrants. The willingness of scientists to change explanations based on evidence, actually results in more reliable information. The early 21st century is a time of quite rapid scientific advancement, characterized by a high rate of both discovery and accumulation of knowledge. Rather then developing "new" theories however, the current explosion of knowledge has greatly expanded the basic and well-accepted principles from physics, chemistry, earth sciences, and biological sciences. Scientists recognize that there will always be new frontiers of science.

Unifying Scientific Concepts and Processes within the Standards

Since early in the 20th century, science is often separated in specific disciplines for study (e.g., physics, chemistry, biology, etc). Nonetheless, students should recognize that broad, unifying concepts and processes exist which cut across traditional scientific disciplines. Five such broad, unifying concepts and processes are embedded within the seven standards. These have been selected from the *National Science Education Standards* because they;

- provide connections between and across traditional scientific disciplines,
- are fundamental and comprehensive,
- can be expressed and experienced in a developmentally appropriate manner in K-12 science education.

The five unifying concepts and processes are:

Systems, Order, and Organization: The world about us is complex; it is too large and complicated to investigate and comprehend all at once. Scientists and students learn to define small portions in order to investigate nature. The units of investigation can be referred to as systems, where a system is an organized group of related objects or components that form a whole. Systems are categorized as open, closed, or isolated, and can consist of organisms, machines, fundamental particles, galaxies, ideas, numbers, and similar phenomena. Systems have boundaries, components, resources, flow (input and output), and feedback. Order - the behavior of units of matter, objects, organisms, or events in the universe - can be described statistically. Probability is the relative certainty (or uncertainty) that individuals can assign to selected events (happening or not happening) in a specified space or time. In science, reduction of uncertainty occurs through such processes as the development of knowledge about factors influencing objects, organisms, systems, or events; better and more observations; and better explanatory models. Types and levels of organization provide useful ways of thinking about the world. Examples of two types of organization include the periodic table of elements and the classification of organisms. Physical systems can be described at different levels of organization - such as fundamental particles, atoms, and molecules. Living systems also have different levels of organization - for example, cells, tissues, organs, organisms, populations, and communities.

Evidence, Models, and Explanation: Evidence consists of observations and empirical data, and is the basis of scientific explanation. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and have explanatory and predictive power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations. Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements.

Constancy, Change, and Measurement: Although most things are in the process of becoming different - changing - some properties of objects and processes are characterized by constancy (e.g., speed of light, charge of an electron, total mass plus energy in the universe). Changes might occur, for example, in properties of materials, position of objects, phenomena in motion, and form and function of systems. Interactions within and among systems create changes. Changes vary in rate, scale, and pattern, including trends and cycles. Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. For example, opposite forces are of the same magnitude, or off-setting changes occur at equal rates. Steady state, balance, and homeostasis also describe equilibrium states. Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible. Changes in systems can be quantified, and evidence for interactions and subsequent change and the formulation of scientific explanations are often clarified through quantitative distinctions - measurement. All measurements are approximations, and the accuracy and precision of measurement depend on equipment, technology, and technique used during observations. Mathematics is essential for accurately measuring change. Different systems of measurement are used for different purposes. Scientists usually use the metric system. An important part of measurement is identifying which system to use. For example a meteorologist might use degrees Fahrenheit when reporting the weather to the public, but in writing scientific reports, the meteorologist would use degrees Celsius.

Patterns of Cumulative Change: Accumulated changes through time, some gradual and some sporadic, account for the present form and function of objects, organisms, and natural systems. The general idea is that the present arises from materials and forms of the past. An example of cumulative change is the formation of galaxies, explained by cosmological theories involving (among other theories) gravitation and the behavior of gasses, and the present diversity of living organisms, explained by the biological theory of evolution, or descent with modification of organisms from common ancestors. The present position of the continents is explained by the theories of continental drift, which involves plate tectonic theory, fossilization, uplift and erosion. Patterns of cumulative change also help to describe the current structure of the universe.

Form and Function: Form and function are complementary aspects of objects, organisms, and systems. The form or shape of an object or system is frequently related to use, operation, or function. Function frequently relies on form. Understanding of form and function applies to different levels of organization. Form and function can explain each other.

Overview of K-12 Kansas Science Education Standards

	Science as Inquiry	Physics & Chemistry	Life Science	Earth & Space Science	Science & Technology	Science in Personal & Environmental Perspectives	History & Nature Of Science
Grades K-4	• Skills necessary to do (full) scientific inquiry; plan and conduct a simple investigation	• Properties of objects • Position & motion of objects; forces • Sound • Electricity, & magnetism	• Organisms and their environments • Life cycles of organisms	• Properties of earth materials • Objects in the sky • Changes in earth & weather	• Technological design; problem solving skills • Apply understanding of science & technology	• Personal health; identify health risks • Changes in the environment	• People practice science
Grades 5-7	• Abilities necessary to do scientific inquiry; design and conduct investigations • Asking scientific questions •Understanding about scientific inquiry	• Measuring and describing properties of matter • Changes in properties of matter • Motions & forces • Transfer of energy	• Function of structures in organisms • Reproduction & heredity • Regulation & behavior • Populations & ecosystems ▪ Diversity & adaptations of organisms	• Changes in structure of the Earth system • Past & present earth processes • Components of the solar system • Motion & forces that effect earth/space phenomena	• Abilities of technological design • Understanding about science & technology	• Apply scientific knowledge to personal health • The effect of human activity on resources & the environment • Risks & causes of natural hazards	• Scientific habits of mind • Contributions to science through-out history
Grades 8-12	• Abilities necessary to do scientific inquiry • Applies technology and mathematics to do scientific inquiry	<u>Chemistry</u> • Structure of atoms • Structure & properties of matter • Chemical reactions <u>Physics</u> • Motions & forces • Conservation of mass and energy; 1st & 2nd Laws of Thermodynamics ▪ Interactions of energy & matter	▪ Structure and function of the cell • Molecular and chromosomal basis of heredity • Biological evolution •Interdependence of organisms with physical environment • Matter, energy, & organization in living systems • Behavior of animals • Diversity of structure and function in organisms	▪ Energy in earth subsystems • Interactions of Earth's subsystems • Origin and development of the earth system • Dynamics of the solar system ▪ Organization and development of the universe	▪ Technology is applied science ▪ Abilities of technological design	▪ Human health and nutrition • Population growth • Human populations, natural resources and environmental quality ▪ Natural & human-induced hazards ▪ Science, technology, and society	▪ Science as a human endeavor ▪ Nature of scientific knowledge ▪ Science from historical perspectives

STANDARD 1: SCIENCE AS INQUIRY **Grades K-2**

SCIENCE AS INQUIRY – The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will be involved in activities that develop skills necessary to conduct scientific inquiries.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. identifies *properties* of objects.	1. states properties of objects such as leaves, shells, rocks, water, and insects.
2. *classifies* and arranges groups of objects by a variety of properties, one property at a time.	2. groups seeds by color, texture, and size; groups objects by whether they float or sink; groups rocks by texture, color, and hardness.
3. uses appropriate materials, *tools,* and *safety procedures* to collect information.	3. a. uses tools such as magnifiers, balances, scales, thermometers, measuring cups, and spoons when engaged in investigations. b. uses appropriate precautions, procedures, and safety equipment when doing investigations.
4. asks and answers questions about objects, organisms, and events in his/her environment.	4. observes and asks questions about a variety of objects and discusses how they are alike and different.
5. describes an observation orally or pictorially.	5. draws pictures of plant growth on a daily basis; notes color, number of leaves; labels plant parts.

Teacher Notes:

These activities involve asking a simple question, completing an investigation, answering the question and presenting the results to others. Not every activity will involve all of these stages nor must any particular sequence of these stages be followed.

Full inquiry – involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. In elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry. They can design investigations to try things to see what happens – they tend to focus on concrete results of tests and will entertain the idea of a "fair" test (a test in which only one variable at a time is changed) (see page 122 in the National Science Education Standards, 1996).

Properties – a word(s) that describe(s) an object based on direct observations using touch, sight, hearing, taste, smell, and measurement.

Classify – a method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change; the test for a good classification system is whether others can use it.
Tools – object(s) used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996).

STANDARD 2: PHYSICAL SCIENCE **Grades K-2**

PHYSICAL SCIENCE - The students will explore the world by observing and manipulating common objects and materials in their environment.

Benchmark 1: All students will develop skills to describe objects.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. observes *properties of objects* and measures or describes those *properties* using age-appropriate tools and materials.	1. measures and compares size, *mass*, shape, color, texture, and temperature of objects.
2. separates or sorts a group of objects or materials by *properties*.	2. compares and sorts objects by shape, size, *mass*, and color.
3. compares the properties of solids and liquids.	3. compares the *properties* of liquid water and frozen water, or liquid (melted) chocolate chips and solid chocolate chips.
4. describes the position of an object in relation to other objects.	4. describes the object's position as being up, down, beside, in front of, or behind the other object.

Teacher Notes:

All students will have opportunities to compare, describe, and sort objects.

Mass - measure of the amount of material something contains.
Properties – a word(s) that describe(s) an object based on direct observations using touch, sight, hearing, taste, smell, and measurement.

STANDARD 3: LIFE SCIENCE **Grades K-2**

LIFE SCIENCE – The student will begin to develop an understanding of biological concepts.

Benchmark 1: The student will develop an understanding of the characteristics of living things.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. discusses that *organisms* live only in *environments* in which their needs can be met.	1. a. learns that children need air, water, food, shelter, and care. b. learns that plants need light, air, water*. c. learns that animals need air, water, food, and shelter.
2. observes *life cycles* of different living things.	2. observes the *life cycles* of butterflies, mealworms, plants, and/or humans.
3. observes living things in various *environments*.	3. observes classroom plants; takes nature walks and field trips in his/her own area; observes terrariums and aquariums.
4. examines the *structures*/parts of living things.	4. observes that butterflies have wings, legs, and antennae; plants have roots, leaves and flowers; and people have a head, a body, skin and hair.

Teacher Notes:

Through direct experiences, students will observe living things, their *life cycles*, and their habitats.

* - like children and animals, plants also require nutrients. Children and animals obtain nutrients and energy from the food they eat. Plants obtain their nutrients from the soil/root media by way of their roots, and energy from the sun.
*Organism*s – any form of life.
Environment – all external conditions and factors, living and non-living that affects an organism during its life time.
Life cycle – the process by which organisms mature, reproduce, and die.
Structures – parts of the organisms that serve different functions in growth, survival, and reproduction.

STANDARD 4: EARTH AND SPACE SCIENCE **Grades K-2**

EARTH AND SPACE SCIENCE – The student will observe closely the objects and materials in their *environment*.

Benchmark 1: The student will describe *properties* of earth materials.

Grades K-2 Indicators	Instructional Examples
The student… 1. observes, compares, and sorts earth materials.	The student… 1 a. describes and compares soils by color and texture; sorts pebbles and rocks by size, shape, and color. b. observes *earth materials* around the playground, on a field trip, or in his/her own yard.
Teacher Notes: Earth materials may include rocks, soils, air, and water. *Environment* - all external conditions and factors, living and non-living that affects an organism during its life time. *Properties* – word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurements. *Earth materials* - rocks, soil, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties which make them useful in different ways.	

STANDARD 4: EARTH AND SPACE SCIENCE **Grades K-2**

EARTH AND SPACE SCIENCE – The student will observe closely the objects and materials in their environment.

Benchmark 2: The student will observe and compare objects in the sky.

Grades K-2 Indicators	Instructional Examples
The student… 1. observes and recognizes the sun, moon, stars, clouds, birds, airplanes, and other objects in the sky. 2. describes that the sun provides light and warmth.	The student… 1. observes day and night sky regularly. 2 a. observes that shadows are formed when an object (buildings, window blinds, clouds, etc.) blocks the sunlight. b. experiences how standing in the shade is cooler than standing in the direct sunlight.
Teacher Notes: The sun, moon, stars, clouds, birds, and other objects such as airplanes have properties that can be observed and compared.	

STANDARD 4: EARTH AND SPACE SCIENCE **Grades K-2**

EARTH AND SPACE SCIENCE – The student will observe closely the objects and materials in their environment.

Benchmark 3: The student will describe changes in weather.

Grades K-2 Indicators	Instructional Examples
The student… 1. observes changes in the weather from day to day. 2. records weather changes daily. 3. discusses weather safety procedures.	The student… 1. draws pictures or uses symbols to record weather observations. 2. uses weather charts, calendars, and logs to record daily weather. 3. practices tornado drill procedures; talks about the dangers of lightning and flooding.
Teacher Notes: Weather includes snow, rain, sleet, wind, and violent storms.	

STANDARD 5: SCIENCE AND TECHNOLOGY **Grades K-2**

SCIENCE AND TECHNOLOGY – The student will have a variety of educational experiences that involve science and *technology*.

Benchmark 1: The student will use technology to learn about the world around them.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. explores the way things work.	1. observes the inner workings of age appropriate toys, wind-up clocks, music boxes, and other mechanical devices.
2. experiences science through *technology*.	2. uses *tools* such as balances, thermometers, hand lenses, bug viewers, and science software programs.
Teacher Notes: Students will use software and other technological resources to discover the world around them. *Technology* – application of knowledge through inventions. *Tools* – object(s) used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996).	

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES **Grades K-2**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will have a variety of experiences that provide understandings for various science-related personal and environmental challenges.

Benchmark 1: The student will demonstrate responsibility for their own health.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. engages in personal care.	1. practices washing hands, brushing teeth, and engaging in exercise; discusses appropriate types of clothing to wear; discusses personal hygiene.
2. discusses healthy foods.	2. explores real fruits and vegetables for textures, tastes, and health value, and/or cuts out pictures of foods and sorts into healthy and not healthy groups.
3. discusses that humans need to practice being safe.	3. discusses the need to obey traffic signals, use crosswalks, and the danger of talking to strangers.
Teacher Notes: This standard should be integrated with physical science, life science, earth and space science standards, and physical education. Health encompasses safety, personal hygiene, exercise, and nutrition.	

STANDARD 7: HISTORY AND NATURE OF SCIENCE **Grades K-2**

HISTORY AND NATURE OF SCIENCE – The student will experience scientific inquiry and learn about people from history.

Benchmark 1: The student will know they practice science.

Grades K-2 Indicators	Instructional Examples
The student…	The student…
1. is involved in explorations that make his/her mind wonder and know that he/she is practicing science.	1. experiences a scientific environment with the teacher leading him/her through the scientific process by asking simple questions, developing simple testable statements (hypotheses), testing the statements by doing simple investigations, and reporting their findings. The following are simple questions that could be used to start the process: a. Does a banana float in water? b. What happens if you hold a chocolate chip in your hand? c. What happens if you rub your hands together very fast?
2. uses *technology* to learn about people in science.	2. reads short stories and views films or videos; listens to guest speakers who are involved in science.
Teacher Notes: This standard should be integrated with physical science, life science, and earth and space science standards. *Technology* – application of knowledge through inventions.	

STANDARD 1: SCIENCE AS INQUIRY **Grades 3-4**

SCIENCE AS INQUIRY – The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will develop the skills necessary to do full inquiry. *Full inquiry* involves asking a simple question, completing an *investigation*, answering the question, and sharing the results with others.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ asks questions that he/she can answer by investigating.	1. asks questions like: will the size of the opening of a container change the rate of evaporation of liquids? How much water will a sponge hold?
2. ▲ plans and conducts a simple investigation.	2. designs a test of the wet strength of paper towels; experiments with plant growth; experiments to find ways to prevent soil erosion.
3. ▲ employs appropriate equipment, *tools*, and safety procedures to gather data.	3. a. uses a balance to find the *mass* of the wet paper towel in grams; uses meter tape to measure the diameter of a rock; uses the same size containers to compare evaporation rates of different liquids. b. uses appropriate precautions, procedures, and safety equipment when conducting *investigations*.
4. ▲ begins developing the abilities to communicate, critique, analyze his/her own *investigations*, and interprets the work of other students.	4. describes *investigations* with pictures, graphs, written language, and oral presentations.

Teacher Notes:

Not every activity will involve all of these stages nor must any particular sequences of these stages be followed.

Full inquiry – involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. In elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry. They can design investigations to try things to see what happens – they tend to focus on concrete results of tests and will entertain the idea of a "fair" test (see page 122 in the National Science Education Standards, 1996). It is developmentally appropriate for elementary level student to test for only one independent variable

Investigation – finding the answer to a question.

Tools – object(s) used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996).

Mass - measure of the amount of material something contains.

▲ = Grade 4 Assessed Indicator

STANDARD 2: PHYSICAL SCIENCE **Grades 3-4**

PHYSICAL SCIENCE - The student will increase their understanding of the *properties* of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and *classify* these materials by observable properties.

Benchmark 1: The student will develop skills to describe objects.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ observes *properties* of objects and measures those *properties* using appropriate *tools*.	1. observes and records the size, *mass*, shape, volume, color, and temperature of objects using balances, thermometers, and other *metric measurement tools*.
2. ▲ describes and *classifies* objects by more than one property.	2. observes that an object could be hard, round, and rough; *classifies* objects by two or more *properties*.
3. ▲ observes and records how one object *interacts* with another object.	3. mixes baking soda and vinegar, or tea bag/food coloring and water, and records observations.
4. ▲ recognizes and describes the differences between solids, liquids, and gases.	4. observes differences between a stick of butter and melted butter, a chocolate bar and melted chocolate, frozen water (ice), water, and water vapor; observes that a solid has a shape of its own and a liquid takes the shape of its container; observes differences between an inflated and a deflated balloon.

Teacher Notes:

Through observation, manipulation, and classification of common objects, children reflect on the similarities and differences of the objects.

Properties – word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurements.

Classify – a method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change; the test for a good classification system is whether others can use it.

Tools – object(s) used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996).

Mass - measure of the amount of material something contains.

Metric measurements – meter, centimeter, millimeter, liter, milliliter, gram, kilogram, Celsius

Interact- when two or more things do something to each other.

▲ = Grade 4 Assessed Indicator

PHYSICAL SCIENCE – The student will increase their understanding of the properties of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and classify these materials by observable properties.

Benchmark 2: The student will describe the motion of objects.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ moves objects by pushing, pulling, throwing, spinning, dropping, and rolling; and describes the motion.	1. spins or rolls a variety of objects on various surfaces and explains how forces (a push or pull) caused the objects to move or stop moving.
2. describes the change in position of objects when moved.	2. describes the objects new position as being above, below, to the right or left, or in front or behind its original position.
Teacher Notes: Students begin to observe the position and movement of objects when they manipulate objects by pushing, pulling, throwing, dropping, and rolling them. ▲ = Grade 4 Assessed Indicator	

PHYSICAL SCIENCE – The student will increase their understanding of the properties of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and classify these materials by observable properties.

Benchmark 3: The student will recognize and demonstrate what makes sounds.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ identifies that the source of sound is vibrations.	1. explores various vibrating objects (tuning forks, rulers, tongue depressors, musical instruments, etc.) that produce sound.
2. discriminates between sounds made by different objects.	2. listens and compares the sounds made by musical instruments and other objects, such as cans, gourds, plastic spoons, pennies, and plastic disks; sorts and classifies a group of objects according to the sounds they make when they are dropped.
3. discriminates between various pitches.	3. identifies high and low pitches.

Teacher Notes:

The concept of sound is very abstract. To make the connection between vibrations and sounds more concrete, have students listen to, touch, and watch the object (tuning fork, audio speaker, ruler on the edge of the table, etc.) being used to produce the sound/vibration. Then attempt to connect the controlled experimental sounds with other observed sounds such as jets rattling windows, intercom speakers, class bells, and that all sounds are ultimately the result of vibrations. However, by investigating a variety of sounds made by common objects, students can form a connection between sounds the objects make and the materials from which the objects are made. Plastic objects make a different sound than do wooden objects, etc.

The relationship between high and low pitches can be explored by causing a tightly and loosely stretched rubber band to vibrate.

▲ = Grade 4 Assessed Indicator

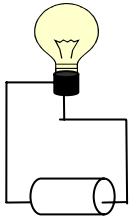
PHYSICAL SCIENCE – The student will increase their understanding of the properties of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and classify these materials by observable properties.

Benchmark 4: The student will experiment with electricity and magnetism.

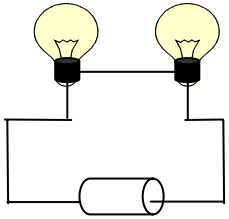
Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ demonstrates that magnets attract and repel.	1 a. explores the *interactions* between two magnets. b. designs a simple experiment with two magnets to show that they attract or repel.
2. designs a simple experiment to determine whether various objects will be attracted to magnets.	2. designs an experiment involving a group of objects to determine which are attracted to or repelled by the magnet.
3. ▲ constructs a *simple circuit.*	3. uses a battery, bulb(s), and wire(s) to make complete circuits i.e. *simple parallel circuit or simple series circuit.*

Teacher Notes:
Magnets attract and repel each other and certain kinds of other materials.
Students will develop the concept that electrical circuits require a complete loop of conductors through which an electric current can pass.
Example circuits:

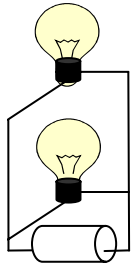
Simple circuit



Series circuit



Parallel circuit



Developmentally, elementary students should be able to build circuit but should not be tested on the difference between types of circuits.
Interact – when two or more things do something to each other,
▲ = Grade 4 Assessed Indicator

STANDARD 3: LIFE SCIENCE **Grades 3-4**

LIFE SCIENCE – The student will develop an understanding of biological concepts through direct experience with living things, their life cycles, and their habitats.

Benchmark 1: The student will develop knowledge of organisms in their environment.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ observes different organisms and compares and contrasts how similar functions are served by different structural characteristics.	1. compares the structures for movement of an insect to the structures for movement of a guppy; compares the leaf structures of a sprouted bean seed to the leaf structures of a corn seed.
2. ▲ compares basic needs of different organisms in their environment.	2. compares the basic needs of an animal to the basic needs of a plant.
3. discusses ways organisms use their senses to survive in their environments.	3. compare how organisms find food, seek shelter (bird nests, beaver dams, etc.), and defend themselves.
Teacher Notes: The study of organisms should include observations and interactions within the natural world of the child. Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking (see pate 129 in the National Science Education Standards, 1996). ▲ = Grade 4 Assessed Indicator	

LIFE SCIENCE – The student will develop an understanding of biological concepts through direct experience with living things, their life cycles, and their habitats.

Benchmark 2: The student will observe and illustrate the life cycles of various organisms.

Grades 3-4 Indicators	Instructional Examples
The student… 1. ▲ compares, contrasts, and asks questions about life cycles of various organisms.	The student… 1. plants a seed and cares for a plant through its life cycle, observing and recording its growth; observes and records the changes of an insect as it develops from birth to adult.
Teacher Notes: Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. Organisms develop into adults that are similar to their parents. ▲ = Grade 4 Assessed Indicator	

STANDARD 4: EARTH AND SPACE SCIENCE **Grades 3-4**

EARTH AND SPACE SCIENCE – The student will observe objects, materials, and changes in their environment, note their properties, distinguish one from another, and develop their own explanations making sense of their observations.

Benchmark 1: The student will develop an understanding of the properties of *earth materials*.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. ▲ collects, observes *properties*, and *classifies* a variety of *earth materials* in his/her *environment*.	1. a. brings in samples of earth materials (rocks, sand, soil, water) from his/her surroundings to observe and classify the samples' by their colors, textures, and other physical properties. b. describes properties of many different kinds of rocks. c. brings rocks from the playground, and observes their colors, and textures when dry as well as when immersed in water; as well as, the reaction when placed in dilute acids (vinegar).
2. experiments with a variety of soil types (clay, silt, sand, and loam).	2. plants seeds in a variety of soils to compare and collect data on the effect of different soils on plant growth; experiments with soil samples and observes how they react to water, wind, compaction, etc…
3. ▲describes *properties* of water and process of the water cycle.	3. a. Observes a water drop using a hand lens to notice shape of the drop (surface tension) and that water is a transparent, odorless, colorless liquid.
4. observes and records the properties of *fossils* and discusses what *fossil*s are.	b. Makes a diagram of the water cycle to show processes of evaporation, condensation, and precipitation. c. Relates the water cycle to observations of weather. Example: forms of precipitation.

Teacher Notes:

Earth materials may include rocks, soil, air, and water. Playgrounds or parks are convenient study sites to observe.

Environment - all external conditions and factors, living and non-living that affects an organism during its life time.
Properties – word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurements.

Fossil - part of a once-living organism or a trace of an organism preserved in rock.

Earth materials - rocks, soil, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties which make them useful in different ways.

Classify – a method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change; the test for a good classification system is whether others can use it.

▲ = Grade 4 Assessed Indicator

EARTH AND SPACE SCIENCE – The student will observe objects, materials, and changes in their environment, note their properties, distinguish one from another, and develop their own explanations making sense of their observations.

Benchmark 2: The student will observe and describe objects in the sky.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. observes the moon and stars.	1. sketches the position of the moon in relation to a tree, rooftop, or building at two or three hourly increments on the same evening.
2. observes and compares the length of shadows.	2. observes the movement of an object's shadow during the course of a day; constructs a simple sundial.
3. ▲ discusses that the sun provides light and heat (electro-magnetic radiation) to maintain the temperature of the earth.	3. discusses why it seems cooler when the sun goes behind a cloud, and then investigates why it is cooler in the shade versus direct sunlight.

Teacher Notes:

The sun, moon, stars, clouds, birds, and other objects such as airplanes have *properties* that can be observed and compared.

Properties – word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurements.

▲ = Grade 4 Assessed Indicator

STANDARD 4: EARTH AND SPACE SCIENCE **Grades 3-4**

EARTH AND SPACE SCIENCE – The student will observe objects, materials, and changes in their environment, note their properties, distinguish one from another, and develop their own explanations making sense of their observations.

Benchmark 3: The student will develop skills necessary to describe changes in the earth and weather.

Grades 3-4 Indicators	Instructional Examples
The student… 1. ▲ describes changes in the surface of the earth. 2. ▲ observes, describes, and records daily and seasonal weather changes.	The student… 1. observes *erosion* at a study site. 2. records weather observations using simple instruments (metric rain gauge, Celsius thermometer, etc.).
Teacher Notes: If the students revisit a study site regularly, they will develop an understanding that the earth's surface and weather are constantly changing. *Erosion* – movement of earth materials from one place to another. ▲ = Grade 4 Assessed Indicator	

STANDARD 5: SCIENCE AND TECHNOLOGY **Grades 3-4**

SCIENCE AND TECHNOLOGY – The student will have a variety of educational experiences which involve science and technology. The student will begin to understand the design process.

Benchmark 1: The student will work with a technology design.

Grades 3-4 Indicators	Instructional Examples
The student… 1. ▲ identifies a simple *design problem* (designs a plan, implements the plan, evaluates the results, makes changes to improve the product, and communicates the results).	The student… 1. a. tries different kinds of tools for making the biggest bubbles or the longest lasting bubbles. b. designs and flies a paper airplane that makes one loop before landing.
Teacher notes: As with the Science as Inquiry Standard, not every activity will involve all stages. Students will develop the ability to solve simple design problems that are appropriate for their developmental level. Teachers should guide students to make only one change at a time to the product as the product is being developed. *Design problem* – developing or inventing a product that accomplishes a task or challenge. ▲ = Grade 4 Assessed Indicator	

STANDARD 5: SCIENCE AND TECHNOLOGY **Grades 3-4**

SCIENCE AND TECHNOLOGY – The student will have a variety of educational experiences which involve science and technology. They will begin to understand the design process.

Benchmark 2: The student will apply their understanding about science and technology.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. will understand that the design process produces knowledge that can be used to solve a problem and improve our world.	1. understands why a zipper was designed; what problem the zipper has solved; how the zipper has improved our lives; how Velcro is like a zipper; what problem Velcro solves; how Velcro has improved our lives.
2. invents a product to solve problems.	2. invents a new use for old products: potato masher, strainer, carrot peeler, or 2 liter pop bottle; uses a juice can, 2 liter pop bottle or one-half gallon milk jug to invent something useful; invents something to solve a problem.
3. works with others to solve problems.	3. solves a problem by working with others, sharing ideas, and testing the solutions.
4. develops an awareness that women and men of all ages, backgrounds, and ethnic groups engage in a variety of scientific and technological work.	4. interviews parents and other community and school workers to determine how they use science and technology in their work.
5. investigates how scientists use *tools* to observe.	5. engages in Internet or library research; interviews or visits a school nurse's, veterinarian's, dentist's, or weatherman's office/laboratory to learn about the *tools* they use.

Teacher notes:

As with the Science as Inquiry Standard, not every activity will involve all stages. Students will develop the ability to solve simple design problems that are appropriate for their developmental level.

Children's abilities in technological problem-solving can be developed by firsthand experiences in tackling tasks with a technological purpose. They can study technological products and systems in their world: zippers, coat hooks, can openers, bridges, paper clips, etc.

Tools – object(s) used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996).

▲ = Grade 4 Assessed Indicator

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES **Grades 3-4**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will demonstrate personal health and environmental practices.

Benchmark 1: The student will develop an understanding of personal health.

Grades 3-4 Indicators	Instructional Examples
The student… 1. ▲ discusses the nutritional value of various foods and their contribution to health. 2. discusses that safety involves preventing injury by avoiding inappropriate risks and dangers. 3. assumes some responsibility for his/her own health, and the health and well being of others.	The student… 1. reads and compares nutrition information found on labels; discusses healthy foods; identifies or makes a healthy snack. 2. takes part in classroom discussions which could include bike safety, water safety, weather safety, sun protection, etc… 3. practices good personal hygiene and cleanliness (including dental); discusses healthy exercise and sleep habits, and practices self-control by abstaining from actions that harm one's self as well as others.
Teacher notes: A variety of experiences will be provided to understand various science-related personal and environmental challenges. This standard should be integrated with physical science, life science, and earth & space science standards, and physical education. Personal health involves physical and mental well being, including hygienic practices, and self-respect. ▲ = Grade 4 Assessed Indicator	

STANDARD 6: SCIENCE IN PERSONALAND ENVIRONMENTAL PERSPECTIVES **Grades 3-4**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will demonstrate personal health and environmental practices.

Benchmark 2: The student will demonstrate an awareness of changes in the environment.

Grades 3-4 Indicators	Instructional Examples
The student… 1. defines pollution. 2. develops personal actions to solve pollution problems in and around the neighborhood. 3. practices reducing, reusing, and recycling.	The student… 1. takes a pollution walk, gathering examples of litter and trash. 2. after the pollution walk, works with other children to solve pollution problems observed. 3. presents the problem that paper is being wasted in the classroom; meets with other students and forms a plan to resolve this problem by considering how the plan is beneficial to others, and consequently, to one's self. The student should recognize that some benefits occur immediately, but many are only gained through longer periods of time.

Teacher notes:

A variety of experiences will be provided to understand various science-related personal and environmental challenges. This standard should be integrated with physical science, life science, and earth & space science standards.

Through classroom discussions, students can begin to recognize pollution as an environmental issue, scarcity as a resource issue, and crowded classrooms or schools as a population issue.

▲ = Grade 4 Assessed Indicator

STANDARD 7: HISTORY AND NATURE OF SCIENCE **Grades 3-4**

HISTORY AND NATURE OF SCIENCE – The student will experience some things about scientific inquiry and learn about people from history.

Benchmark 1: The student will develop awareness that people practice science.

Grades 3-4 Indicators	Instructional Examples
The student…	The student…
1. recognizes that students participate in science inquiry by asking questions.	1. asks questions such as: How are plants affected by various amounts of light? Which is the "best" paper towel (define best)? Which liquid causes substances such as a jawbreaker, chocolate candy, and Jell-O to dissolve more quickly?
2. studies the lives of people who made scientific contributions.	2. reads short stories; views films or videos; discusses contributions made by people in science.

Teacher notes:

Experiences of investigating and thinking about explanations provide fundamental ideas about the history and nature of science. Students will observe and compare, pose questions, gather data and report findings. Posing questions and reporting findings are human activities that all students are able to understand. Science is not just memorizing information. This standard should be integrated with physical science, life science, and earth and space science standards.

Science and technology have been practiced by people for a long time. Children and adults can derive great pleasure from doing science. They can investigate and experience science. Individuals, as well as groups of students, can conduct investigations.

Teachers need to help students understand that asking questions is the beginning of doing science.

▲ = Grade 4 Assessed Indicator

STANDARD 1: SCIENCE AS INQUIRY **Grades 5-7**

SCIENCE AS INQUIRY – The student will develop the abilities to do *scientific inquiry*, be able to demonstrate how *scientific inquiry* is applied, and develop understandings about *scientific inquiry*.

Benchmark 1: The student will demonstrate abilities necessary to do the processes of *scientific inquiry*.

Grades 5-7 Indicators	Instructional Examples
The student….	The student…
1. ▲ identifies questions that can be answered through scientific investigations.	1. explores properties and phenomena of various materials and generates testable questions to investigate.
2. ▲ designs and conducts *scientific investigations* safely using appropriate tools, mathematics, *technology*, and techniques to gather, analyze, and interpret data.	2. a. designs and conducts an investigation on a question; example, What is the effect of light on plant growth? Components of the investigation may include background and hypothesis, identification of variables (independent variable, dependent variable, variables to be held constant), list of materials, procedures, collection and analysis of data, and conclusions. b. given an investigative question, determines what to measure and how to measure. c. displays data collected from performing in investigation using tables, graphs, diagrams and other graphic organizers.
3. ▲ identifies the relationship between evidence and logical conclusions.	3. a. checks data to determine: Was the question addressed? Was the hypothesis supported/not supported? Did this design work? How could this experiment be improved? What other questions could be investigated? b. looks for patterns from the mean of multiple trials, such as the rate of dissolving relative to different temperatures. c. uses observations for inductive and deductive reasoning, such as explaining a person's energy level after a change in eating habits (e.g., uses Likert-type scale).

	d. states relationships in data, such as variables, which vary directly or inversely.
4. ▲ communicates scientific procedures, results and explanations.	4. Presents a report of his/her investigation so that others understand it and can replicate the design.

TEACHER NOTES:

Given appropriate curriculum and adequate instruction, students can develop the skills of investigation and the understanding that scientific inquiry is guided by knowledge, observations, questions, and a design which identifies and controls variables to gather evidence to formulate an answer to an original question. Students are to be provided opportunities to engage in full and partial inquiries in order to develop the skills of inquiry.

Teachers can facilitate success by providing guidelines or boundaries for studying inquiry. Teachers assist students in choosing interesting questions, monitoring design plans, providing relevant examples of effective observation and organization strategies, and checking and improving skills in the use of instruments, technology, and techniques. Students at the middle level need special guidance in using evidence to build explanations, inferences, and models, guidance to think critically and logically, and to see the relationships between evidence and explanations.

Scientific investigation – A scientific investigation uses scientific inquiry to ask an answer a question.

Technology - Creates products to meet human needs by applying scientific principles. Science and technology are reciprocal. Science helps drive technology. Technology is essential to science, because it provides instruments and techniques that promote scientific inquiry.

▲ = Grade 7 Assessed Indicator

STANDARD 1: SCIENCE AS INQUIRY **Grades 5-7**

SCIENCE AS INQUIRY – The student will develop the abilities to do scientific inquiry, be able to demonstrate how scientific inquiry is applied, and develop understandings about scientific inquiry.

Benchmark 2: The student will apply different kinds of investigations to different kinds of questions.

Grades 5-7 Indicators	Instructional Examples
The student….	The student…
1. develops questions and adapts (frames) the inquiry process to guide the appropriate type of investigation.	1 a. after reading a science news article, identifies variables and writes an appropriate investigative question related to the topic of the article. b. adapts an existing lab or activity to write a different question, identify another variable, and/or modify the procedure to guide a new investigation.
2. differentiates between qualitative and quantitative data in an investigation	2. observes a decomposing compost pile, and determines how to collect quantitative (numerical, measurable) data and qualitative (descriptive) data. Identifies a question that produces quantitative date. (e.g., is the temperature constant throughout the compost pile?) Identifies a question that produces qualitative data. (e.g., does the color of the compost pile change over time?) With the class, analyzes all questions to classify as qualitative or quantitative.

TEACHER NOTES:

Some investigations involve observing and describing objects, organisms or events. Investigations can also involve collecting specimens, experiments, seeking more information, discovering new objects and phenomena, and creating models to explain the phenomena. Instructional activities of scientific inquiry need to engage students in identifying and shaping questions for investigations. Different kinds of questions suggest different kinds of investigations. Many processes or objects in science cannot be directly observed due to size distance or other constraints. However, scientific evidence can be used to draw conclusions and develop a model or picture of the process or object.

To help focus, students need to frame questions such as “What do we want to find out?” “How can we make the most accurate observations?” “If we do this, then what do we expect to happen?” Students need instruction to develop the ability to refine and refocus broad and ill-defined questions.

SCIENCE AS INQUIRY – The student will develop the abilities to do scientific inquiry, be able to demonstrate how scientific inquiry is applied, and develop understandings about scientific inquiry.

Benchmark 3: The student will analyze how science advances through the interaction of new ideas, scientific investigations, skepticism, and examinations of evidence of varied explanations

Grades 5-7 Indicators	Instructional Examples
The student… 1. after completing an investigation, generates alternative methods of investigation and/or further questions for inquiry. 2. ▲ evaluates the work of others to determine evidence which scientifically supports or contradicts the results, identifying faulty reasoning or conclusions that go beyond evidence and/or are not supported by data.	The student… 1. asks "What would happen if…?" questions to generate new ideas for investigation. 2 a. examines and analyzes a scientific breakthrough (such as a Hubble discovery) using multiple scientific sources. b. explains how a reasonable conclusion is supported. c. analyzes evidence and data which supports or contradicts various theories (e.g. theory of continental drift, spontaneous generation, etc...).

TEACHER NOTES:

Scientific investigations often result in new ideas and phenomena for study. These generate new investigations in the scientific community. Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the proposed explanations by examining and comparing evidence, identifying faulty reasoning, and suggesting other alternatives.

Much time can be spent asking students to scrutinize evidence and explanations, but to develop critical thinking skills students must be allowed this time. Data that are carefully recorded and communicated can be reviewed and revisited frequently providing insights beyond the original investigative period. This teaching and learning strategy allows students to discuss, debate, question, explain, clarify, compare, and propose new thinking through social discourse. Students will apply this strategy to their own investigations and to scientific theories.

▲ = Grade 7 Assessed Indicator

PHYSICAL SCIENCE – The student will apply process skills to develop an understanding of physical science including: properties, changes of properties of matter, motion and forces, and transfer of energy.

Benchmark 1: The student will observe, compare, and classify properties of matter.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ compares and classifies the states of matter; solids, liquids, gases, and plasma	1. makes a diagram/model showing the various states of water demonstrating that the molecules of a solid has definite volume and shape, the molecules of a liquid have a definite volume but an indefinite shape, the molecules of a gas have an indefinite volume and indefinite shape.
2. compares and contrasts the classes of matter; elements, compounds, and mixtures.	2 a. separates sand, iron filings, and salt using a magnet and water. b. observes properties of kitchen powders (baking soda, salt, sugar, flour). Mixes in various combinations, then identifies by properties. c. given a chemical formula, uses a periodic table to identify the number and type elements in a compound.
3. identifies and communicates properties of matter including but not limited to, boiling point, solubility, and density.	3 a. measures and graphs the boiling point temperatures for several different liquids. b. graphs the cooling curve of a freezing ice cream mixture. c. observes substances that dissolve (sugar) and substances that do not dissolve (sand).

TEACHER NOTES:

Substances have characteristic properties. Substances often are placed in categories if they react or act in similar ways. An example of a category is metals. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and non-living substances we encounter. Middle level students have the capability of understanding relationships among properties of matter. For example, they are able to understand that density is a ratio of mass to volume, boiling point is affected by atmospheric pressure, and solubility is dependent on pressure and temperature.

These relationships are developed by concrete activities that involve hands-on manipulation of apparatus, making quantitative measurements, and interpreting data using graphs. It is important to connect characteristics of matter to common experiences so that concepts can be reconstructed. Some relevant questions are “What happens in a pressure cooker?” “Why does adding oil to boiling rice and pasta keep it from boiling over?” “What is in antifreeze and how does it keep your radiator from freezing?” “Why do bridges have metal expansion joints?”

▲ = Grade 7 Assessed Indicator

PHYSICAL SCIENCE – The student will apply process skills to develop an understanding of physical science including: properties, changes of properties of matter, motion and forces, and transfer of energy.

Benchmark 2: The student will observe, measure, infer, and classify changes in properties of matter.

Grades 5-7 Indicators	Instructional Examples
The student… 1. ▲ understands the relationship of atoms to elements and elements to compounds. 2. ▲ measures and graphs the effects of temperature on matter.	The student… 1. draws a diagram to show how different compounds are composed of elements in various combinations. 2. changes water from solid to liquid to gas using heat. Measures and graphs temperature changes. Observes changes in volume occupied.

TEACHER NOTES:

Substances react chemically in characteristic ways with other substances to form new substances (compounds) with different characteristic properties. Middle level students have the capability of inferring characteristics that are not directly observable and stating their reasons for their inferences. Students need opportunities to form relationships between what they can see and their inferences of characteristics of matter.

We cannot always see the products of chemical reactions, so the teacher can provide opportunities for students to measure reactants and products to build the concept of conservation of mass. "Is mass lost when baking soda (solid) and vinegar (liquid) react to produce a gas?" "How could we design an experiment which would (safely) contain the reaction in a closed container in order to measure the materials before and after the reaction?" Students need to engage in activities that lead to these understandings.

▲ = Grade 7 Assessed Indicator

PHYSICAL SCIENCE – The student will apply process skills to develop an understanding of physical science including: properties, changes of properties of matter, motion and forces, and transfer of energy.

Benchmark 3: The student will investigate motion and forces.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. identifies the forces that act on an object (e.g., gravity and friction)	1. a. explores the variables of (wheel and ramp) surfaces that would allow a powered car to overcome the forces of gravity and friction to climb an inclined plane. b. investigate the forces acting on an airplane (thrust, drag, lift, and gravity).
2. ▲ describes, measures, and represents data on a graph showing the motion of an object (position, direction of motion, speed).	2 a. follows the path of a toy car down a ramp that is first covered with tile and then with sandpaper. b**.** traces the force, direction, and speed of a baseball, from leaving the pitcher's hand and returning back to the pitcher through one of many possible paths. c. rolls a marble down a ramp. Makes adjustments to the board or to the marble's position in order to hit a target located on the floor. Measures and graphs the results.
3. ▲ recognizes and describes examples of Newton's Laws of Motion.	3 a. places a small object on a rolling toy vehicle, stops the vehicle abruptly, and observes the motion of the small object. Relates to personal experience - stopping rapidly in a car. b. with a ping pong ball and 2 straws, investigates the effects of the force of air through two straws on the ping-pong ball with the straws at the same side of the ball, on opposite sides, and at other angles. Illustrates results with vectors (force arrows). d. researches safety equipment, such as seat belts and safety helmets, and the role they play related to inertia.

4. ▲investigates and explains how simple machines multiply force at the expense of distance.	4 a. investigates the load (force) that can be moved as the number of pulleys in a system is increased. b. investigates how bicycle gears work.

TEACHER NOTES:

All matter is subjected to forces that affect its position and motion. Relating motions to direction, amount of force, and/or speed allows students to graphically represent data for making comparisons. A moving object that is not being subjected to a force will continue to move in a straight line at a constant speed. The principle of inertia helps to explain many events such as sports actions, household accidents, and space walks. If more than one force acts upon an object moving along a straight line, the forces may reinforce each other or cancel each other out, depending on their direction and magnitude.

Students experience forces and motions in their daily lives when kicking balls, riding in a car, and walking on ice. Teachers should provide hands-on opportunities for students to experience these physical principles. The forces acting on natural and human-made structures can be analyzed using - computer simulations, physical models, and games such as pool, soccer, bowling, and marbles.

Weight – The response of mass to the pull of gravity. Weight is a measure of force. Note: Weight is often confused with mass. Mass is the amount matter (stuff) an object has and is not dependent on the object's location. Weight is a measure of force and is not constant because the pull of gravity on an object's mass varies with location. An object would weight less on Earth than on Jupiter because Jupiter has greater mass than Earth; Jupiter's mass would have a greater gravitational attraction for the object.

▲ = Grade 7 Assessed Indicator

PHYSICAL SCIENCE – The student will apply process skills to develop an understanding of physical science including: properties, changes of properties of matter, motion and forces, and transfer of energy.

Benchmark 4: The student will understand and demonstrate the transfer of energy.

Grades 5-7 Indicators	Instructional Examples
The student… 1. understands the difference between potential and kinetic energy. 2. ▲ understands that when work is done energy transforms from one form to another, including mechanical, heat, light, sound, electrical, chemical, and nuclear energy, yet is conserved. 3. ▲ observes and communicates how light (electromagnetic) energy interacts with matter: transmitted, reflected, refracted, and absorbed. 4. ▲ understands that heat energy can be transferred from hot to cold by radiation, convection, and conduction.	The student… 1. uses a pendulum to compare kinetic energy (speed) with potential energy (height). 2. a. sequences the transmission of energy through various real-life systems. b. designs an energy-transfer device using various forms of energy that will accomplish a simple task, such as popping a balloon. c. draws a chart of energy flow through a telephone from the caller's voice to the listener's ear. 3. classifies classroom objects as to how they interact with light: a window transmits; black paper absorbs; a pencil appears to bend when placed in water demonstrating refraction; a mirror reflects. 4. adds colored warm water to cool water. Observes convection. Measures and graphs temperature over time.

TEACHER NOTES:
Energy forms, such as heat, light, electricity, mechanical (motion), sound, and chemical energy are properties of substances. Energy can be transformed from one form to another. The sun is the ultimate source of energy for life systems, while heat convection currents deep within the earth are energy sources for gradually shaping the earth's surface. Energy cycles through physical and living systems. Energy can be measured and predictions can be made based on these measurements.
Students can explore light energy using lenses and mirrors, then connect with real-life applications such as cameras, eyeglasses, telescopes, and bar code scanners. Students connect the importance of energy transfer with sources of energy for their homes, such as chemical, nuclear, solar, and mechanical sources. Teachers provide opportunities for students to explore and experience energy forms, energy transfers, and make measurements to describe relationships.

▲ = Grade 7 Assessed Indicator

STANDARD 3: LIFE SCIENCE **Grades 5-7**

LIFE SCIENCE – The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

Benchmark 1: The student will model structures of organisms and relate functions to the structures.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ will understand the cell theory; that all organisms are composed of one or more cells, cells are the basic unit of life, and that cells come from other cells.	1. will observe plant and animal cells using a microscope.
2. ▲ relates the structure of cells, organs, tissues, organ systems, and whole organisms to their functions	2. creates and compares two models: the major parts and their functions of a single-cell organism and the major parts and their functions of a multi-cellular organism, e.g. amoeba and hydra.
3. compares organisms composed of single cells with organisms that are multi-cellular.	3. a. identifies human body organs and characteristics. Then relates their characteristics to function. b. maps human body systems, researches their functions and shows how each supports the health of the human body. c. relates an organism's structure to how it works. d. compare and contrast plant and animal cells.
4. concludes that breakdowns in structure or function may be caused by disease, damage, heredity, or aging.	4. compares lung capacity of smokers with that of non-smokers and graphs the results.

TEACHER NOTES:

The cell theory states that organisms are made of cells, cells are the basic unit of life, and cells come from other cells. Living things at all levels of organization demonstrate the complimentary nature of structure and function. Disease is a breakdown in structure or function of an organism. It is useful for middle level students to think of life as being organized from simple to complex, such as a complex organ system includes simpler structures. Understanding the structure and function of a cell can help explain what is happening in more complex systems. Students must also understand how parts relate to the whole, such as each structure is distinct and has a set of functions that serves the

whole.

Teachers can help students understand this organization of life by comparing and contrasting the levels of organization in both plants and animals. Teachers reinforce understanding of the cellular nature of life by providing opportunities to observe live cultures, such as pond water, creating models of cells, and using the Internet to observe and describe electron micrographs. Early adolescence is an ideal time to investigate the human body systems as an example of relating structure and function of parts to the whole.

▲ = Grade 7 Assessed Indicator

LIFE SCIENCE – The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

Benchmark 2: The student will understand the role of reproduction and heredity for all living things.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ differentiates between asexual and sexual reproduction of organisms. .	1. a. compares the regeneration of a planarian to the reproduction of an earthworm. b. compares the propagation of new plants from cuttings, which skips a portion of the life cycle, with the process of producing a new plant from fertilization of an ovum. c. observes and communicates the life cycle of an organism.
2. understands how hereditary information of each cell is passed from one generation to the next	2. a. in a cooperative setting, traces parent characteristics with those of an offspring using Punnett squares. b. uses coin tossing to predict the probability of traits being passed on.
3. infers that the characteristics of an organism result from heredity and interactions with the environment	3. chooses an organism. Researches its characteristics. Infers if these characteristics result from heredity, environment, or both.

TEACHER NOTES:
Reproduction is an activity of all living systems to ensure the continuation of every species. Organisms reproduce sexually and/or asexually. Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another. Students need to clarify misconceptions about reproduction, specifically about the role of the sperm and egg, and the sexual reproduction of flowering plants. In learning about heredity, younger middle level students will focus on observable traits, and older students will gain understanding that genetic material carries coded information.
Teachers should provide opportunities for students to observe a variety of organisms and their sexual and asexual methods of reproduction by culturing bacteria, yeast cells, paramecia, hydra, mealworms, guppies, or frogs. Tracing the origin of students' own development back to sperm and egg reinforces how an organism develops from a combination of male and female sex cells. Discussions with students about traits they possess from their father and mother lead to understanding of how an organism receives genetic information from both parents and how new combinations result in the students' unique characteristics.
▲ = Grade 7 Assessed Indicator

STANDARD 3: LIFE SCIENCE **Grades 5-7**

LIFE SCIENCE – The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

Benchmark 3: The student will describe homeostasis, the regulation and balance of internal conditions in response to a changing external environment. .

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ understands that internal and/or environmental conditions affect an organism's behavior and/or response in order to maintain and regulate stable internal conditions to survive in a continually changing environment.	1 a. selects a variable to alter the environment (e.g., temperature, light, moisture, gravity) and observes the effects on an organism (e.g., pill bug or earthworm). Thinks of his/her own behaviors and determines environmental conditions that affect behavior.
	b. observes the response of the body when competing in a running event. (In order to maintain body temperature, various systems begin cooling through such processes as sweating and cooling the blood at the surface of the skin).
2. recognizes that the survival of all organisms requires the ingestion of materials, the intake and release of energy, growth, release of wastes and responses to environmental change.	c. investigates the effects of various stimuli on plants and how they adapt their growth: phototropism, geotropism, and thermotropism are examples.

TEACHER NOTES:

All organisms perform similar processes to maintain life. They take in food and gases, eliminate wastes, grow and progress through their life cycle, reproduce, and maintain stable internal conditions while living in a constantly changing environment. An organism's behavior changes as its environment changes. Students need opportunities to investigate a variety of organisms to realize that all living things have similar fundamental needs. After observing an organism's way of moving, obtaining food, and responding to danger, students can alter the environment and observe the effects on the organism.

This is an appropriate time to study the human nervous and endocrine systems. Students can compare and contrast how messages are sent through the body and how the body responds. An example is how fright causes changes within the body, preparing it for fighting or fleeing.

▲ = Grade 7 Assessed Indicator

LIFE SCIENCE – The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

Benchmark 4: The student will identify and relate interactions of populations of organisms within an ecosystem.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ recognizes that all populations living together (biotic resources) and the physical factors (abiotic resources) with which they interact compose an ecosystem.	1 a. creates a classroom terrarium and identifies the interactions between the populations and physical conditions needed for survival. b. participates in a field study examining the living and non-living parts of a community.
2. understands how limiting factors determine the carrying capacity of an ecosystem.	2 changes variables such as wheat crop yield, mice, or a predator, and chart the possible outcomes. (For example, how would a low population of mice affect the population of the predator over time)?
3. ▲ traces the energy flow from the sun (source of radiant energy) to producers (via photosynthesis – chemical energy) to consumers and decomposers in food webs.	3 a. explores populations at a stream, pond, field, forest floor, and/or rotting log. Identifies the various food webs and observes that organisms in a system are classified by their function. b. role-plays the interactions and energy flow of organisms in a food web e.g. Passes a ball of string among a circle of students who represent parts of a food web (green plants, the sun, insects, etc…). (The string connecting students represents the relationships among food web components, resulting in a web-like model). c. investigates the importance of photosynthesis to all life.

TEACHER NOTES:

A population consists of all individuals of a species that occur together at a given time and place. All populations living together and the physical factors with which they interact compose an ecosystem. Populations can be categorized by the functions they serve in an ecosystem: producers (make their own food), consumers (obtain food by eating other organisms), and decomposers (use waste materials).

The major source of energy for ecosystems is sunlight. This energy enters the ecosystem as sunlight and is transformed by producers into food (chemical) energy which then passes from organism to organism, which we observe as food webs. The resources of an ecosystem, biotic and abiotic, determine the number of organisms within a population that can be supported.

Middle level students understand populations and ecosystems best when they have an opportunity to explore them actively. Taking students to a pond or a field, or even having them observe life under a rotting log, allows them to identify and observe interactions between populations and identify the physical conditions needed for their survival. A classroom terrarium, aquarium, or river tank can serve as an excellent model for observing ecosystems and changes and interactions that occur over time between populations of organisms and changes in physical conditions. Constructing their own food webs, given a set of organisms, helps students to see multiple relationships more clearly.

▲ = Grade 7 Assessed Indicator

LIFE SCIENCE – The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

Benchmark 5: The student will observe the diversity of living things and relate their adaptations to their survival or extinction.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. concludes that species of animals, plants, and microorganisms may look dissimilar on the outside but have similarities in internal structures, developmental characteristics, chemical processes, and genomes.	1. a. researches numerous organisms and creates a classification system based on observations of similarities and differences. b. uses a field guide and/or dichotomous key to identify an organism. c. explores various ways animals take in oxygen and give off carbon dioxide.
2. ▲ understands that adaptations of organisms (changes in structure, function, or behavior that accumulate over successive generations) contribute to biological diversity.	2. compares characteristics of birds such as beaks, wings, and feet, with how a bird behaves in its environment. Then works in a cooperative group to design different parts of an imaginary bird. Relates characteristics and behaviors of that bird with its structures.
3. ▲ associates extinction of a species with environmental changes and insufficient adaptive characteristics.	3. uses various objects to model bird beaks, such as spoons, toothpicks, clothespins. Uses “beaks” to “eat” several types of food, such as cereal, raisins, noodles. (When “food” sources change, those species that have not adapted die).

TEACHER NOTES:

Millions of species of animals, plants and microorganisms are alive today. Animals and plants vary in body plans and internal structures. The theory of biological evolution explains how gradual changes of characteristics of organisms over many generations have resulted in variations among populations and species. Therefore, a structural characteristic, process, or behavior that helps an organism survive in its environment is called an adaptation. When the environment changes and the adaptive characteristics are insufficient, the species becomes extinct.

As they investigate different types of organisms, teachers guide students toward thinking about similarities and differences. Students can

compare similarities between organisms in different parts of the world, such as tigers in Asia and mountain lions in North America to explore the concept of common ancestry. Instruction needs to be designed to uncover and correct misconceptions about natural selection. Students tend to think of all individuals in a population responding to change quickly rather than over a long period of time. Using examples such as Darwin's finches help develop understanding of natural selection over time. Providing students with fossil evidence and allowing them time to construct their own explanations is important in developing middle level students' understanding of extinction as a natural process that has affected earth's species over time.

▲ = Grade 7 Assessed Indicator

EARTH and SPACE SCIENCE – The student will apply process skills to explore and develop an understanding of the structure of the earth system, earth's history, and earth in the solar system.

Benchmark 1: The student will understand that the structure of the earth system is continuously changing due to earth's physical and chemical processes.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ identifies properties of the solid earth, the oceans and fresh water, and the atmosphere.	1 a. classifies rocks, minerals, and soil by properties. b. creates a concept map of earth materials using links to show connections, such as water causing erosion of solid rock, wind evaporating water, etc… c. investigates water's major role in changing the solid surface of earth, such as the effect of oceans on climates and water as an erosion force. d. maps major climate zones and relates to ocean currents. e. compares heating and cooling over land and water. f. compares the densities of salt and fresh water.
2. ▲ models earth's cycles, constructive and destructive processes, and weather systems.	2 a. creates rock cycle and water cycle dioramas. b. illustrates global ocean and wind currents. c. constructs models of rock types using food. Peanut brittle without the peanuts can illustrate a molten material crystallizing to form a solid substance similar to an igneous rock. d. observes the effects of mechanical and chemical weathering on various rock types. e. investigates local examples of weathering, erosion, and deposition.

TEACHER NOTES:

Earth has four major interacting systems: the geosphere, the atmosphere, the hydrosphere, and the biosphere. Earth (geosphere) material is constantly being reworked and changed. Physical forces, chemical reactions, heat, energy, and biological processes power the rock cycle and the water cycle. The outermost layer of the earth is the lithosphere. Under the lithosphere is a hot, convecting mantle and a dense, metal-rich core. Massive lithospheric plates containing continents and oceans move slowly in response to movement in the mantle. These plate motions also result in earthquakes, volcanoes, and mountain building. Constructive and destructive forces change earth's landforms. Constructive forces include crustal formation by plate movement, volcanic eruptions, earthquakes, and deposition of sediments. Destructive forces include weathering, erosion, and glacial action.

Students learn about the major earth systems and their relationships through direct and indirect evidence. First-hand observations of weather, rocks, soil, oceans, and gases lead students to make inferences about some of those major systems. Indirect evidence is used when determining the composition and movement in earth's mantle and core.

▲ = Grade 7 Assessed Indicator

STANDARD 4: EARTH and SPACE SCIENCE **Grades 5-7**

EARTH and SPACE SCIENCE – The student will apply process skills to explore and develop an understanding of the structure of the earth system, earth's history, and earth in the solar system.

Benchmark 2: The student will understand past and present earth processes and their similarity.

Grades 5-7 Indicators	Instructional Examples
The student… 1. ▲ understands that earth processes observed today (including movement of lithospheric plates and changes in atmospheric conditions) are similar to those that occurred in the past; earth history is also influenced by occasional catastrophes, such as the impact of a comet or asteroid.	The student… 1 a. makes models which show how erosion and deposition has changed Earth's surface over time. b. investigate how the Grand Canyon was formed and continues to change.

TEACHER NOTES:

The constructive and destructive forces we see today are similar to those that occurred in the past. Earth's history is written in the layers of the rocks, and clues in the rocks can be used to piece together a story and picture. Geologic processes that form rocks and mountains today are similar to processes that formed rocks and mountains over a long period of time in the distant past.

Teachers can provide opportunities for students to observe and research evidence of changes that can be found in earth's crust. Sedimentary rocks, such as limestone, sandstone, and shale show deposition of sediments over time. Volcanic flows of ancient volcanoes and earthquake damage can show us what to expect from modern day catastrophes. Glacial deposits show past ice ages and global warming and cooling. Some fossil beds enable the matching of rocks from different continents, and other fossil beds show how organisms developed over a long period of time. Students will need to apply knowledge of earth's past to make decisions relative to earth's future.

▲ = Grade 7 Assessed Indicator

EARTH and SPACE SCIENCE – The student will apply process skills to explore and develop an understanding of the structure of the earth system, earth's history, and earth in the solar system.

Benchmark 3: The student will identify and classify stars, planets, and other solar system components.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. ▲ compares and contrasts the characteristics of stars, planets, moons, comets, and asteroids.	1 a. identifies the sun as a star and compares its characteristics to those of other stars. b. classifies bright stars visible from earth by color, temperature, age, apparent brightness, and distance from earth. c. creates a graphic organizer to visualize comparisons of planets. d. identifies and classifies characteristics of asteroids and comets.
2. models spatial relationships of the earth/moon/planets/sun system to scale.	2. models the solar system to scale in a long hallway or school yard using rocks for rocky planets and balloons for gaseous planets. Designates a large object as the sun. Models the earth/moon/sun system to scale with the question: If earth were the size of a tennis ball, how big would the moon be? How big would the sun be? How far apart would they be?
3. identifies past and present methods used to explore space..	3. researches ancient observations and explanations of the heavens and compares with today's knowledge and methods such as, how we learn about phenomena/objects we can't observe directly. Ex. Spectral analysis to determine the chemistry of stars.

TEACHER NOTES:

The solar system consists of the sun, which is an average-sized star in the middle of its life cycle, and the nine planets and their moons, asteroids, and comets, which travel in elliptical orbits around the sun. The sun, the central and largest body in the system, radiates energy outward. Earth is the third of nine planets in the system, and has one moon. Other stars in our galaxy are visible from earth, as are distant galaxies, but are so distant they appear as pinpoints of light. Scientists have discovered much about the composition and size of stars, and how they move in space. Space and the solar system are of high interest to middle level students. Teachers can help students take advantage of the many print and on-line resources, as well as by becoming amateur sky-watchers.

▲ = Grade 7 Assessed Indicator

STANDARD 4: EARTH and SPACE SCIENCE **Grades 5-7**

EARTH and SPACE SCIENCE – The student will apply process skills to explore and develop an understanding of the structure of the earth system, earth's history, and earth in the solar system.

Benchmark 4: The student will model motions and identify forces that explain earth phenomena.

Grades 5-7 Indicators	Instructional Examples
The student…	The student...
1. ▲ demonstrates and models object/space/time relationships that explain phenomena such as the day, the month, the year, seasons, phases of the moon, eclipses and tides.	1 a. uses an earth/moon/sun model to demonstrate a day, a month, a year, and the seasons. b. models the relative positions of the sun, earth, and moon to create eclipses, phases of the moon, and tides.
2. describes how the angle of incidence of solar energy striking earth's surface affects the amount of heat energy absorbed at earth's surface.	2. places a piece of graph paper on the surface of a globe at the equator. Holds a flashlight 10 cm. from the paper perpendicular to the globe. Marks the lighted area of the paper. Then, places the graph paper at high latitude. Again holds the flashlight perpendicular to the paper 10 cm from the paper. Compares the areas lit at the equator and at the high latitude, with the same amount of light energy. Identifies where each lighted square of paper receive the most energy?

TEACHER NOTES:

There are many motions and forces that affect earth. Most objects in the solar system have regular motions, which can be tracked, measured, analyzed, and predicted. These motions can explain such phenomena as the day, year, seasons, tides, phases of the moon, and eclipses of the sun and moon. The force that governs the motions within the solar system, keeps the planets in orbit around the sun, and the moon in orbit around the earth is gravity. Phenomena on earth's surface, such as winds, ocean currents, the water cycle, and the growth of plants, receive their energy from the sun.

Misconceptions abound among middle level students about concepts such as the cause of the seasons and the reasons for the phases of the moon. Hands-on activities, role-playing, models, and computer simulations are helpful for understanding the relative motion of the planets and moons. Many ideas are misconceptions which could be considered in a series of "what if" questions: What if the sun's energy did not cause cloud formation and other parts of the water cycle? What if the earth rotated once a month? What if the earth's axis were not tilted?

▲ = Grade 7 Assessed Indicator

STANDARD 5: SCIENCE AND TECHNOLOGY **Grades 5-7**

SCIENCE AND TECHNOLOGY – The student will demonstrate abilities of technological design and understandings about science and technology.

Benchmark 1: The student will demonstrate abilities of technological design.

Grades 5-7 Indicators	Instructional Examples
The student… 1. identifies appropriate problems for technological design, designs a solution or product, implements the proposed design, evaluates the product, and communicates the process of technological design.	The student… 1 a. designs a measurement instrument (e.g., weather instrument) for a science question that students are investigating. b. selects and researches a current technology, then projects how it might change in the next twenty years. c. designs, creates and evaluates a product that meets a need or solves a problem in a student's life. d. keeps a log of designing (and building) a technology, then uses the log to explain the process.

TEACHER NOTES:
Technological design focuses on meeting human needs, solving human problems or developing a product. Students need to develop abilities to identify specific needs and design solutions for those needs. The tasks of technological design include addressing a range of needs, materials, and aspects of science. Suitable experiences could include designing inventions that meet a need in the student's life.

Building a tower of straws is a good start for collaboration and work in design preparation and construction. Students need to develop criteria for evaluating their inventions/products. These questions could help develop criteria: Who will be the users of the product? How will we know if the product meets their needs? Are there any risks to the design? What is the cost? How much time will it take to build? Using their own criteria, students can design several ways of solving a problem and evaluate the best approach. Students could keep a log of their designs and evaluations to communicate the process of technological design. The log might address these questions: What is the function of the device? How does the device work? How did students come up with the idea? What were the sequential steps taken in constructing the design? What problems were encountered?

For more information see pages 161 - 166 of the National Science Education Standards.

▲ = Grade 7 Assessed Indicator

SCIENCE AND TECHNOLOGY – The student will demonstrate abilities of technological design and understandings about science and technology.

Benchmark 2: The student will develop understandings of the similarities, differences, and relationships in science and technology.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. compares the work of various types of scientists and engineers.	1. Completes a Venn diagram to compare the processes of scientists and engineers.
2. evaluates benefits, risks, limitations and trade-offs of technological solutions.	2. selects a technology to evaluate using a graphic organizer listing uses, limitations, and possible consequences.
3. identifies contributions to science and technology by many people and many cultures.	3. using a map of the world, marks the locations for people and events that have contributed to science.

TEACHER NOTES:

The primary difference between science and technology is that science investigates to answer questions about the natural world and technology creates a product to meet human needs by applying scientific principles. Middle level students are able to evaluate the impact of technologies, recognizing that most have both benefits and risks to society. Science and technology have advanced through contributions of many different people, in different cultures, at different times in history.

Students may compare and contrast scientific discoveries with advances in technological design. Students may select a device they use, such as a radio, microwave, or television, and compare it to one their grandparents used.

▲ = Grade 7 Assessed Indicator

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will apply process skills to explore and develop an understanding of issues of personal health, population, resources and environment, and natural hazards.

Benchmark 1: The student will understand scientific knowledge relative to personal health.

Grades 5-7 Indicators	Instructional Examples
The student… 1. ▲ identifies individual nutrition, exercise, and a rest needs based on science and uses a scientific approach to thinking critically about personal health, lifestyle choices, risks and benefits.	The student… 1 a. designs, implements, and self-evaluates a personal nutrition and exercise program. b. compares and contrasts immediate benefits of eating junk food (high caloric, low nutritional foods) to long term benefits of a lifetime of healthy eating. c. evaluates the risks and benefits of foods, medicines, and personal products. d. evaluates and compares the nutritional and toxic properties of various natural and synthetic foods.

TEACHER NOTES:
Regular exercise, rest, and proper nutrition are important to the maintenance and improvement of human health. Injury and illness are risks to maintaining health. Middle level students need opportunities to apply scientific knowledge to their understanding of personal health and science-based decision-making related to health risks.

Teachers should understand that the decision making capacities of ten, eleven, twelve and thirteen year-old children are not fully developed, are subject to significant interference from hormonal changes, and otherwise lack the experience and maturity of an adult that may be necessary for wise and prudent decisions about their lives. Accordingly, teachers should work to reinforce normative parental and legal expectations designed to optimize their personal health. The challenge to teachers is to show students how science validates legal and normative parental expectations and requirements about health issues such as smoking, use of alcohol, disease, healthy eating, and the wearing of seat belts and helmets and why it is in their best personal interests to comply with these healthy expectations and requirements.

▲ = Grade 7 Assessed Indicator

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES **Grades 5-7**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will apply process skills to explore and develop an understanding of issues of personal health, population, resources and environment, and natural hazards.

Benchmark 2: The student will understand the impact of human activity on resources and environment.

Grades 5-7 Indicators	Instructional Examples
The student… 1. ▲ investigates the effects of human activities on the environment and analyzes decisions based on the knowledge of benefits and risks.	The student… 1 a. counts the number of cars that pass the school during a period of time. Investigates the effects of traffic volume on environmental quality (e.g., water and air quality, plant health). b. investigates the effects of repeatedly walking off the sidewalks. Discusses the implications for the environment. c. participates in an environmental study, such as stream monitoring. d. evaluates the benefits of burning fossil fuels to meet energy needs against the risks of increased air pollution, etc…

TEACHER NOTES:
When an area becomes overpopulated by a species, the environment will change due to the increased use of resources. Middle level students need opportunities to learn about concepts of carrying capacity. They need to gather evidence and analyze effects of human interactions with the environment.

Teachers can help their students understand these global issues by starting locally. "What changes in the atmosphere are caused by all the cars we use in our community?" Ground level ozone indicators provide an opportunity to quantify the effect. "After a heavy rain, where does the water go that runs off your lawn?" "What happens to that water source if your lawn was fertilized just before the rain?" The role of the teacher is to help students apply scientific understanding, gained through their own investigations, of environmental issues. Teachers should help students base environmental decisions on understanding, not emotion.

▲ = Grade 7 Assessed Indicator

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES **Grades 5-7**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will apply process skills to explore and develop an understanding of issues of personal health, population, resources and environment, and natural hazards.

Benchmark 3: The student will understand that natural hazards are dynamic examples of earth processes which cause us to evaluate risks.

Grades 5-7 Indicators	Instructional Examples
The student…	The student…
1. recognizes patterns of natural processes and/or human activities that may cause and/or contribute to natural hazards.	1 a. sees how channeling a stream may promote flooding downstream. Could use a County Conservation Commission's stream trailer to investigate the dynamics of a stream and the effects of human interaction with the stream.
2. evaluates risks and defines appropriate actions associated with the natural hazard.	2 a. finds news articles that show inadvisable risks taken in a natural hazard situation. b. investigates appropriate safety procedures for dealing with various natural hazards e.g. Tornados, floods, lightning, etc…

TEACHER NOTES:

California has earthquakes. Florida has hurricanes. Kansas has tornadoes. Natural hazards can also be caused by human interaction with the environment, such as channeling a stream. Middle level students need opportunities to identify the causes and human risks and challenges of natural hazards.

Teachers can help students use data on frequency of occurrence of natural hazard events both to dispel unnatural fears for some students and overcome the common middle level student misconception of invincibility (it won't happen to me). "What would you need in a tornado survival kit to keep in the basement for your family?" This question would cause students to assess the kinds of damage caused by a tornado (need a flashlight because electrical lines may be down) and the kinds of support services available in the community.

▲ = Grade 7 Assessed Indicator

STANDARD 7: HISTORY AND NATURE OF SCIENCE **Grades 5-7**

HISTORY AND NATURE OF SCIENCE – The student will examine and develop an understanding of science as a historical human endeavor.

Benchmark 1: The student will develop scientific habits of mind.

Grades 5-7 Indicators	Instructional Examples
The student… 1. practices intellectual honesty, demonstrates skepticism appropriately, displays open-mindedness to new ideas, and bases decisions on evidence.	The student… 1 a. analyzes news articles to determine whether data/statistics presented adequately and objectively support conclusions that are made. b. analyzes data and recognizes that a hypothesis not supported by data should not be perceived as a right or wrong answer. c. attempts to replicate an investigation to support or refute a conclusion. d. shares interpretations that differ from currently held explanations on topics such as global warming and dietary claims. Evaluates the validity of results and accuracy of stated conclusions. e. reviews results of individual, group, or peer investigations to assess the accuracy of conclusions based upon data collection and analysis and use of evidence to reach a conclusion.

TEACHER NOTES:

Science requires varied abilities depending on the field of study, type of inquiry, and cultural context. The abilities characteristic of those engaged in scientific investigations include: reasoning, intellectual honesty, tolerance of ambiguity, appropriate skepticism, open-mindedness, and the ability to make logical conclusions based on current evidence.

Teachers can support the development of scientific habits of mind by providing students with on-going instruction using inquiry as a framework. Students can apply science concepts in investigations. They can work individually and on teams while conducting inquiry. They can share their work through varied media, and they can self-evaluate their learning. High expectations for accuracy, reliability, and openness to differing opinions should be exercised.

HISTORY AND NATURE OF SCIENCE – The student will examine and develop an understanding of science as a historical human endeavor.

Benchmark 2: The student will research contributions to science throughout history.

Grades 5-7 Indicators	Instructional Examples
The student… 1. ▲ recognizes that new knowledge leads to new questions and new discoveries, replicates historic experiments to understand principles of science, and relates contributions of men and women to the fields of science.	The student… 1 a. discusses discoveries that replaced previously held knowledge, such as safety of Freon or saccharine use, knowledge concerning the transmission of AIDS, cloning, or Pluto's status as a planet. b. rediscovers principles of electromagnetism by replicating Oersted's compass needle experiment. (Compass needle deflects perpendicular to current carrying wire.) c. researches the contributions of men and women of science, and creates a timeline to demonstrate the ongoing contributions of dedicated scientists across ethnic, religious, and gender lines.

TEACHER NOTES:

Scientific knowledge is not static. New knowledge leads to new questions and new discoveries that may be beneficial or harmful. Contributions to scientific knowledge can be met with resistance, causing a need for replication and open sharing of ideas. Scientific contributions have been made over an expanse of time by individuals from varied cultures, ethnic backgrounds, and across gender and economic boundaries.

Students should engage in research realizing that the process may be a small portion of a larger process or of an event that takes place over a broad historical context. Teachers should focus on the contributions of scientists and how the culture of the time influenced their work. Reading biographies, interviews with scientists, and analyzing vignettes are strategies for understanding the role of scientists and the contributions of science throughout history.

▲ = Grade 7 Assessed Indicator

SCIENCE AS INQUIRY – The student will develop the abilities necessary to do scientific inquiry and develop an understanding of scientific inquiry.

Benchmark 1: The student will demonstrate the abilities necessary to do scientific inquiry.

Grades 8-12 Indicators	Additional Specificity
The student…	
1. actively engages in asking and evaluating research questions.	1. Well-formed research questions drive scientific inquiry.
2. ▲ actively engages in investigations, including developing questions, gathering and analyzing data, and designing and conducting research	2. The scientific investigations includes, when appropriate, a. formulating a testable hypothesis. b. identify and test variables (independent, dependent, and variables to be kept constant). c. using methods for gathering data that is observable, measurable, and replicable. d. analyzing and evaluating the results in order to clarify the questions and hypotheses, and to refine methods for further research.
3. ▲ actively engages in using technological tools and mathematics in their own scientific investigations.	3. a. using a variety of technologies, such as hand tools, measuring instruments, calculators, and computers as an integral component of scientific investigations. b. using common mathematical functions to analyze and describe data. c. uses statistical and graphing data analysis techniques. d. recognizes that the accuracy and precision of the data, and therefore the quality of the investigation, depends on the instruments used. f. using equipment properly and safely.

4. actively engages in conducting an inquiry, formulating and revising his or her scientific explanations and models (physical, conceptual, or mathematical) using logic and evidence, and recognizing that potential alternative explanations and models should be considered.	4. a. engages in discussions that result in the revision of his/her explanation. b. analyzes their explanation by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models have the greatest explanatory power. c. evaluates personal preconceptions and biases with respect to his/her conclusions. d. based on their results, students consider modifications to their investigations.
5. actively engages in communicating and defending the design, results, and conclusion of his/her investigation.	5. a. writes procedures, expresses concepts, reviews information, summarizes data, and uses language appropriately. b. develops diagrams and charts to summarize and analyze data. c. presents information clearly and logically, both orally and in writing. d. constructs reasoned arguments. e. responds appropriately to critical comments.
Teacher Notes: Students actively involved in asking and answering their own questions, can connect the science they are learning in the classroom with real-world applications. ▲ = High School Assessed Indicator	

CHEMISTRY – The student will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 1: The student will understand the structure of the atom.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands atoms, the fundamental organizational unit of matter, are composed of subatomic particles. Chemists are primarily interested in the protons, electrons, and neutrons found in the atom.	1 a. All atoms are identified by the number of protons in the nucleus, i.e. the atomic number. The protons have a positive charge and a mass of 1 amu. Protons and neutrons are found in the small, dense, nucleus. b. Neutrons have a neutral charge and a mass of 1 amu. c. The electrons have a negative charge and are found outside the nucleus in an electron cloud. The mass of an electron is approximately 2,000 times smaller than a proton. The electrons determine the size and chemical properties of the atom. d. The number of electrons is equal to the number of protons in a neutral atom. Ions have a different number of electrons than protons. e.
2. understands isotopes are atoms with the same atomic number (same number of protons) but different numbers of neutrons. The nuclei of some atoms are radioactive isotopes that spontaneously decay, releasing radioactive energy.	2 a. The periodic table reflects the average mass of the isotopes. b. Examples of released radioactivity are alpha, beta, and gamma radiation. c. Some isotopes spontaneously decay at a first order rate. There is a negative linear relationship between the log of the sample isotope concentration vs. time,

	d. To balance a nuclear equation, the sum of the atomic numbers and the sum of the mass numbers must be equal on both sides of the equation.
Teacher Notes: These concepts are basic to physics, chemistry, biology, earth/space science. ▲ = High School Assessed Indicator	

CHEMISTRY – The student will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 2: The students will understand the states and properties of matter.

Grades 8-12 Indicators	Additional Specificity
The student … 1. ▲ understands chemists use kinetic and potential energy to explain the physical and chemical properties of matter on earth that may exist in any of these three states: solids, liquids, and gases.	1a. Elements and molecules may exist as gases, liquids or solids. Ionic compounds most commonly exist as solids. b. Intermolecular attraction (attraction between molecules) determines the state of the molecule. Examples of intermolecular attraction include hydrogen bonding, permanent dipole interaction, and induced dipole interaction. Gases have the weakest and solids have the greatest intermolecular attraction. The hydrogen bond is an intermolecular attraction responsible for the properties of water and many biological molecules.
2. ▲ understands the periodic table lists elements according to increasing atomic number. This table organizes physical and chemical trends by groups, periods, and sub-categories.	2a. Elements in the same group have the same number of valence electrons and can be used to predict similar physical and chemical properties. Elements are grouped by similar ground state valence electron configurations. b. As periods increase, the principle energy levels of the outermost (*valence*) electrons increase Electrons changing from one energy level to another may result in the emission or absorption of various forms of electromagnetic radiation, including the range of colors that form visible light. When there is color, there are electrons changing energy levels. c. Sub-categories are regions such as metals, non-metals, and transition elements Nonmetals have different physical and chemical properties than metals. For example, nonmetals have lower melting points, lower density, and are poorer conductors of electricity and heat. Chemical properties depend on the subshell of the valence electrons which are different for metals and non-metals.

3. ▲ understands chemical bonds result when valence electrons are transferred or shared between atoms. Breaking a chemical bond requires energy. Formation of a chemical bond releases energy. Ionic compounds result from atoms transferring electrons. Molecular compounds result from atoms sharing electrons. For example, carbon atoms can bond to each other in chains, rings, and branching networks. Branched network and metallic solids also result from bonding.	3 a. Valence electron configurations determine whether an atom gains, loses, or shares electrons to achieve a more stable electron configuration similar to the noble gases. b. Positively charged ions are called cations, and negatively charged ions are called anions. Cations are attracted to anions (opposite charges attract). Most cations are metals; most anions are nonmetals. In stable ionic compounds, the sum of the charges is zero. c. Covalent bonds form when two or more atoms share one or more pairs of electrons to achieve a more stable electron configuration. The two classifications of covalent bonds are nonpolar and polar. The greater the electronegativity difference between atoms involved in the bond, the more polar the bond. d. The energy required to break ionic bonds is greater than the energy required to break covalent bonds. Heat exchange during a chemical reaction is often easily noticed: a reaction that absorbs heat will feel colder; a reaction that releases heat will feel warmer. e. Carbon atoms can bond to each other in chains, rings, and branching networks to form a variety of molecular structures including relatively large molecules essential to life. Diamonds, a 3-dimensional branching of carbon atoms and quartz, a repeated 3-dimensional branching of silicon dioxide molecules, are further examples of network solids. Unique properties of network solids include hardness, high melting points, poor conductors - indicative of covalent bonding and stable geometry. f. Metallic bonding is defined as free roaming electrons forming a negative sea of electrons surrounding the positive metal ions.
Teacher Notes: The states and classes of matter are introduce in Grade 3-4 and further developed in the Grades 5-7. Grades 8-12 students should be able to explain these concepts at an advanced molecular level. ▲ = High School Assessed Indicator	

CHEMISTRY – The students will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 3: The student will gain a basic concept of chemical reactions.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands a chemical reaction occurs when one or more substances (reactants) react to form a different chemical substance(s) (products). There are different types of chemical reactions all of which demonstrate the Law of Conservation of Matter and Energy.	1a. Chemical reactions are written as balanced chemical equations. In ordinary chemical reactions, the number and kind of atoms must be conserved. b. Examples of chemical reactions are synthesis, decomposition, combustion, single and double replacement, acid/base, and oxidation/reduction. c. Two or more of the following may often identify chemical reactions: physical property change, effervescence, mass change, precipitation, light emission, and heat exchange. d. The rate (speed) of a chemical reaction depends on such parameters as temperature, concentration, catalysts, inhibitors, surface area, and reaction type.
2. understands how to perform mathematical calculations regarding the Law of Conservation of Matter, i.e., through stoichiometric relationships.	2a..Reaction stoichiometry involves understanding the use of coefficients (moles) to balance equations and solve for a variety of relationships using the molar mass of the substances. Examples of these types of relationships include mole/mole, mole/mass, mole/volume, mass/volume, mass/mass, etc.
3. understands the differences and reactions between acids, bases, and salts. Perform calculations to determine the concentration of ions in solutions.	3a. Acids react with bases to produce water and salt. b. pH is a logarithmic function of hydronium ion concentration. pH decreases as the hydronium ion concentration increases. pOH and hydroxide concentrations are found in a similar way.

	c. Determination of an unknown base may be determined by experimental titration and use of Ma X Va = Mb X Vb. d. Dilution formulas (M1 X V1 = M2 X V2) can be used to determine the concentration of a solution after diluting it with water.
Teacher Notes: ▲ = High School Assessed Indicator	

PHYSICS – The student will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 1: The student will understand the relationships between force and motion.

Grade 8-12 Indicators	Additional Specificity
The student …	
1. ▲understands Newton's Laws and the variables of time, position, velocity, and acceleration can be used to describe the position and motion of particles.	1. a. The kinematic (motion) variables: position, velocity, and acceleration can most concisely be described as vectors. b. Velocity describes how position changes and acceleration describes how velocity changes. c. From the definitions of velocity and acceleration, one can derive equations that relate the kinematic variables. d. Acceleration occurs when there is either a change in speed or a change in direction. In the case of uniform circular motion, the acceleration points towards the center of the circle. The magnitude of this acceleration is constant, and is related to the speed of the object and the radius of the circle. e. In the absence of a net force, an object's velocity will not change. f. In the presence of a net force, an object will experience an acceleration which is modeled mathematically by Newton's second law. f. The force that one object exerts on a second object has the same magnitude but opposite direction as the force that the second object exerts on the first.
2. understands physicists use conservation laws to analyze the motion of objects.	2. a. Mechanical energy is conserved when no non-conservative forces (such as friction) do work. b. The momentum of an object is a product of its mass and velocity. Momentum is conserved when there are no external forces on the system.

	c. There are situations in which momentum is conserved but mechanical energy is not. Forces internal to a system can cause a loss of mechanical energy, but only external forces can change the system's momentum. d. Angular momentum is conserved when there is no external torques on the system.
Teacher Notes: ▲ = High School Assessed Indicator	

PHYSICS – The student will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 2: The student will understand the conservation of mass and energy, and the First and Second Laws of Thermodynamics.

Grade 8-12 Indicators	Additional Specificity
The student …	
1. understands matter has energy. Mass and energy can be interchanged. The total energy in the universe is constant, but the type of energy may vary.	1. a. The amount of energy in a given amount of mass at rest is given by $E = mc^2$. b. The amount of energy that would be required to completely dissociate a nucleus into its constituent protons and neutrons, divided by the number of protons and neutrons, is known as the "binding energy per nucleon" of the nucleus. c. Two light nuclei that merge into a larger nucleus emit energy. This is known as fusion. d. A massive nucleus that splits apart into two medium mass nuclei emit energy. This is known as fission.
2. ▲understands the first law of thermodynamics states the total internal energy of a substance (the sum of all the kinetic and potential energies of its constituent molecules) will change only if heat is exchanged with the environment or work is done on or by the substance. In any physical interaction, the total energy in the universe is conserved.	2. a. There are different manifestations of energy. Kinetic energy is the energy an object possesses due to its motion. Gravitational potential energy is the energy due to the separation of masses. Electric potential energy is the energy due to the separation of charges. Kinetic and potential energy combined are known as mechanical energy. b. Heat is an exchange of internal (kinetic and/or potential) energy between systems due to a temperature difference. Heat flows spontaneously from hot objects to cooler ones. It does not flow spontaneously in the other direction. Heat can be made to flow from cooler objects to warmer ones if one does work. A heat engine can convert heat to work, but some heat will always be lost in the process. Examples of heat transport include radiation from the sun, convection of hydrosphere/atmosphere/mantle, and conduction between water/land/air.

	c. A force that has a component parallel to the direction of motion of an object is said to do work on that object. The work done on an object may be positive or negative. When positive work is done on an object, it increases the object's energy. Negative work decreases it. d. There is a relationship between energy and power. Power is the rate at which work is done, or the rate at which the energy of some system changes.
3. understands the second law of thermodynamics that states the entropy of the universe is increasing.	3. a. Entropy is a state function that describes a system. In some cases, it can be thought of as a measure of disorder. A system will not spontaneously undergo a process that decreases its entropy. b. A discretely defined system; a collection of objects or particles interacting via forces or processes that are internal to the system, remains the same or become more disordered (i.e. losing heat across the boundary of the system) over time.
Teacher Notes: ▲ = High School Assessed Indicator	

PHYSICS – The student will develop an understanding of the structure of atoms, *compounds,* chemical reactions, and the interactions of energy and matter.

Benchmark 3: The student will understand the nature of the fundamental interactions of matter and energy.

Grade 8-12 Indicators	Additional Specificity
The student …	
1. There are four fundamental forces in nature: strong nuclear force, weak nuclear force, electromagnetic force, and gravitational force.	1. a. The strong nuclear force keeps particles together in atomic nuclei. b. The weak nuclear force plays a role in the radioactive disintegration of certain nuclei. c. The strong and weak nuclear forces act on quarks and leptons, subatomic particles. d. The electromagnetic force is the force that charged particles exert on one another. The electric force between any two charged particles is given by Coulomb's law, which state that the force is inversely proportional to the square of the distance between the charges. The magnetic force occurs between any two charged particles moving relative to each other. e. The gravitational force is the attractive force that objects exert on one another due to their mass. The gravitational force between any two masses is given by Newton's law of universal gravitation, which states that the force is inversely proportional to the square of the distance between the masses. This explains the motion of planets. Near the surface of the Earth, the acceleration of an object due to gravity is independent of the mass of the object and therefore constant.
2. ▲understands waves have energy and can transfer energy when they interact with matter.	2. a. Waves are traveling disturbances which transport energy without the bulk motion of matter. In transverse waves, the disturbance is perpendicular to the direction of travel. In longitudinal waves, the disturbance is parallel to the direction of travel. b. There are many different types of waves. Examples are water waves, sound waves, and electromagnetic waves. Visible light, radio waves, and X-rays are all examples of electromagnetic waves. Periodic waves can also be described in terms of their wavelength, frequency, period, and amplitude.

	c. All waves can be described in terms of their velocities. The velocity of most types of waves depends on the medium in which they are traveling. There is a relationship between the speed, wavelength, and frequency of a periodic wave. The frequency of sound waves is related to the pitch we perceive. Difference wavelengths of visible light correspond to different colors.
3. The student understand interference – how waves interact with other waves	3. a. Most common types of waves obey the principle of linear superposition. When two waves meet, they superimpose. At points where the crests (or troughs) of two waves meet there is constructive interference. At points where the crest of one wave meets the through of another, there is destructive interference. Beats are heard when two sound waves with slightly different frequencies interfere. Two waves traveling in opposite directions can combine to produce a standing wave. b. Diffraction is the bending of a wave around an obstacle or an edge. When this happens, different intensities of the wave are observed downstream due to the wave interfering with itself.
4. The student will understand the principles of reflection and refraction.	4. a. When light reflects from a surface, the angle of incidence is equal to the angle of reflection. When light propagates from one transparent medium to another, it bends (refracts) at the interface in a manner given by Snell's law. One can trace rays to predict the properties of images produced by mirrors. One can trace rays to predict the properties of images produced by lenses.
5. ▲ understands electromagnetic waves result when a charged particle is accelerated or decelerated.	5. a. Electromagnetic waves include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. The energy of electromagnetic waves is carried in packets and has a magnitude that is inversely proportional to the wavelength.** b. Some particles, such as protons and electrons, have a physical property known as charge. There are two types of charge, known as positive and negative. c. Charged particles experience a force given by Coulomb's law. Coulomb's law indicates that the electric force between two charges is attractive if the charges have opposite sign, and repulsive if they have the same sign. The force between charges is inversely proportional to the square of the distance between them. d. The magnitude of the magnetic force on a particle in a magnetic field is proportional to the particle's charge and speed, and to the magnitude of the magnetic field. The direction of the force is perpendicular to both the particle's velocity and the magnetic field. If the particle's velocity is parallel to the magnetic field, the force vanishes.

6. The student understands basic electrostatics and circuits.	6. a. There is a potential energy associated with the electric force. This is most commonly dealt with in the related quantity electric potential. The electric potential energy of a particle is its charge times the electric potential at the particle's location. b. Knowledge of electric force and potential allows for the analysis of simple DC circuits. Batteries increase the electric potential energy of electrons. Although it is electrons that flow in a circuit, we analyze circuits as if positive charges are flowing in the other direction. Current is the rate at which charges are flowing in a circuit. The electric potential in a conductor has the same value everywhere in that conductor. Positive charges flowing through a resistor experience a drop in electric potential given by Ohm's law. Charges flowing through a resistor lose energy at a rate that depends on the current and on the resistance of the resistor. The resistance of resistors in series or in parallel can be computed, given the resistances of each individual resistor.
Teacher Notes: ▲ = High School Assessed Indicator	

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 1: The student will demonstrate an understanding of the structure and function of the cell.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands cells are composed of a variety of specialized structures that carry out specific functions.	1. a. Each cell is surrounded by a membrane that controls the flow of materials into and out of the cell. b. Proteins embedded in the membranes help carry out specific life processes such as transport and recognition. c. In eukaryotes, similar membranes compartmentalize various chemical environments of the cell into organelles such as the nucleus and mitochondria. d. Organelles carry out specific life functions for the cell such as protein synthesis, protein processing and packaging, energy transformation, communication, etc…
2. ▲ understands cell functions involve specific chemical reactions.	2. a. Food molecules taken into cells provide the chemicals needed to synthesize other molecules. b. Enzymes catalyze both breakdown and synthesis in the cell.
3. understands cells function and replicate as a result of information stored in DNA and RNA molecules.	3. a. Gene expression regulates cell functions through the synthesis of proteins. b. This regulation allows cells to respond to their environment and to control and coordinate cell division.
4. understands some plant cells contain chloroplasts, which are the sites of photosynthesis.	4. The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems.
5. understands cells can differentiate, thereby enabling complex multicellular organisms to form.	5. a. In the development of most multicellular organisms, a fertilized cell forms an embryo that differentiates into an adult.

Teacher Notes:

The life science standards provide a framework for a variety of courses in the life sciences. All of the indicators listed for this benchmark would be appropriate for inclusion in a high school biology course. The study of microbiology, as a separate course or within a biology course, would focus on unicellular organisms and viruses, and would generally not include indicators 4 and 5. Even courses that focus on animals, such as zoology, might include indicator 4, since photosynthesis provides the energy that drives most food chains. Local curriculum is based on the concepts of the Standards, but is more specific.

▲ = High School Assessed Indicator

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 2: The student will demonstrate an understanding of chromosomes, genes, and the molecular basis of heredity.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands living organisms contain DNA or RNA as their genetic material, which provides the instructions that specify the characteristics of organisms.	1. a. Nucleotides (adenine, thymine, guanine, cytosine and uracil) make up DNA and RNA molecules. b. Sequences of nucleotides that either determine or contribute to a genetic trait are called genes. c. DNA is replicated by using a template process that usually results in identical copies. d. DNA and associated proteins supercoil during cellular replication to become structured as chromosomes.
2. understands organisms usually have a characteristic number of chromosomes; one pair of these may determine the sex of individuals.	6. Most cells in humans contain 23 pairs of chromosomes; the 23rd pair usually contains the XX for female or XY for male.
3. ▲ understands hereditary information is contained in genes, located in the chromosomes of each cell.	3. a. An inherited trait of an individual can be determined by one gene or by many genes (a polygenic trait), and a single gene can influence more than one trait. b. The expression of traits is determined by a complex interaction of genes and the environment. c. Alleles, which are different forms of a gene, may be dominant, recessive, or co-dominant.

4. understands gametes carry the genetic information to the next generation.	4. a. Gametes usually contain only one member from each chromosome pair. b. Gametes unite to form a new individual in most organisms.
5. understands expressed mutations occur in DNA at very low rates.	5. a. Mutations are genetic changes and can be beneficial, neutral, or deleterious. Many mutations have deleterious effect on the organism's survival and/or reproduction. b. Only mutations in gametes can be passed on to offspring and thus affect future generations. c. Mutations in somatic cells can affect the individual organism, but not its offspring.
Teacher Notes: The life science standards provide a framework for a variety of courses in the life sciences. All of the indicators listed for this standard would be appropriate for inclusion in a high school biology course, and may be included in any organismal biology class. The indicators provide a basis for developing local curriculum for a course focusing on genetics. ▲ = High School Assessed Indicator	

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 3: The student will understand biological evolution.

Grades 8-12 Indicators	Additional Specificity
The student …	
1 ▲understands biological evolution, descent with modification, is a scientific explanation for the history of the diversification of organisms from common ancestors	1. a. The presence of the same materials and processes of heredity (DNA, replication, transcription, translation, etc.) is used as evidence for the common ancestry of modern organisms. b. Patterns of diversification and extinction of organisms are documented in the fossil record. Evidence indicates that simple, bacteria-like life may have existed billions of years ago. c. The distribution of fossil and modern organisms is related to geological and ecological changes (i.e. plate tectonics, migration). There are observable similarities and differences among fossils and living organisms. d. The frequency of heritable traits may change over a period of generations within a population of organisms, usually when resource availability and environmental conditions change as a consequence of extinctions, geologic events, and/or changes in climate.
2. understands populations of organisms adapt to environmental challenges and changes as a result of natural selection, genetic drift, and various mechanisms of genetic change.	2. a. Genetic changes occur only in individual organisms. b. Natural selection and genetic drift occur within populations or organisms. c. Variation among individuals in a population allows individuals to respond differently to environmental challenges.

3. ▲ understands biological evolution is used to explain the earth's present day biodiversity: the number, variety and variability of organisms.	3. a. Separate populations within a species may become sufficiently different enough that new species develop. This process is called speciation. b. Changes in inherited traits accumulate in populations. c. Historically only a small percentage of species have survived to modern times.
4. ▲ understands organisms vary widely within and between populations. Variation allows for natural selection to occur.	4. a. Heritable variation exists in every species. b. New heritable traits result from new combinations of genes and from mutations or changes in the reproductive cells. c. Variation of organisms within and among species increases the likelihood that some members will survive under changing environmental conditions. d. Times, populations, or entire lineages become extinct. One effect of this is to increase the differences between the surviving lineages.
5. understands the primary mechanism acting on variation is natural selection.	5. a. Favorable heritable traits are more advantageous to reproduction and/or survival than others. b. There is a finite supply of resources available for offspring; therefore not all survive. c. Individuals with beneficial traits generally survive to reproduce in greater numbers. d. Favorable heritable traits tend to increase in the population through time if the selective pressure is maintained.

6. understands biological evolution is used as a broad, unifying theoretical framework for biology.	6. a. Organisms are classified and according to the rules of nomenclature, and are given scientific names. b. The behavioral, physical, and genetic characteristics upon which these classifications are based are used as evidence for common descent. g. Natural selection, genetic drift, genomes, and the mechanisms of genetic change provide a context in which to ask research questions and help explain observed changes in populations.

Teacher Notes:

See introduction pages x – xiii for more information on the Nature of Science.
The life science standards provide a framework for a variety of courses in the life sciences. Evolution is a key theoretical framework for the life sciences.

These indicators should be part of any life science course curriculum, including biology, botany, zoology and microbiology.

▲ = High School Assessed Indicator

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 4: The student will understand the interdependence of organisms and their interaction with the physical environment.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.	1. The essential chemical elements for life circulate in the *biosphere* in characteristic paths known as biogeochemical cycles (e.g., cycles for water, nitrogen, carbon, oxygen, etc)
2. understands energy is received, transformed and expended in ecosystems.	2. a. Radiant energy that enters the biosphere is balanced by the energy that leaves the earth into space as radiant energy, primarily heat. b. Transfer of energy through a series of organisms in an ecosystem is known as a food web. c. Organisms and ecosystems expend energy, much of which is released as heat, to maintain a high state of internal order.
3. ▲ understands the distribution and abundance of organisms and populations in ecosystems are limited by the carrying capacity.	3. a. The carrying capacity is determined by the availability of matter and energy, and the ability of the ecosystem to recycle materials. b. Living organisms produce more offspring than environmental resources can support, resulting in a competition for resources
4. understands organisms cooperate and compete in complex, interdependent relationships	4. These relationships include; a. predator-prey relationships b. symbiotic relationships (parasitism, mutualism, commensalisms).
5. understands human beings live within and impact ecosystems.	5. a. Humans modify ecosystems as a result of population growth, technology, and consumption. b. Human modifications of habitats through direct harvesting, pollution, atmospheric changes, and other factors affect ecosystem stability.

Teacher Notes:

The life science standards provide a framework for a variety of courses in the life sciences. Ecology concepts are key to understanding life; these indicators provide a framework for local curriculum for courses such as biology, botany, and zoology.

Learning Science in the Outdoors: Varied experiences in the outdoors make natural processes less abstract and are critical to developing scientific literacy. Teachers are encouraged to create outdoor learning experiences for their students.

▲ = High School Assessed Indicator

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 5: The student will develop an understanding of matter, energy, and organization in living systems.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands living systems require a continuous input of energy to maintain their chemical and physical organization.	1. Without the input of energy, all matter tends toward more disorganized states. With death and the cessation of energy intake, living systems rapidly disintegrate.
2. ▲ understands the sun is the primary source of energy for life through the process of photosynthesis.	2. a. Plants and other photosynthetic organisms use energy to make organic compounds (primarily glucose) from carbon dioxide and water (CO_2 and H_2O) through a series of biochemical reactions. b. The energy in these compounds is used to assemble larger molecules with biological activity, including proteins, DNA, carbohydrates, and fats. c. These molecules serve as sources of energy for the plants themselves and for many other organisms through food webs. d. Chemosynthetic organisms, unlike photosynthetic organisms, use energy from chemical compounds to maintain life functions.

3. ▲ understands food molecules contain biochemical energy, which is then available for cellular respiration. 4. understands the structure and function of an organism serve to acquire, transform, transport, release, and eliminate the matter and energy used to sustain the organism.	3. a. Energy is released when the food molecules are broken down into simpler compounds b. Energy is transferred to ATP through cellular respiration c. Most biochemical reactions, fueled by ATP, are catalyzed by enzymes.
Teacher Notes: The life science standards provide a framework for a variety of courses in the life sciences. This benchmark integrates important physical science and earth science concepts into the study of life. These indicators may be included in local curriculum in any life science course. ▲ = High School Assessed Indicator	

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 6: The student will understand the behavior of animals.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands animals have behavioral responses to internal changes and to external stimuli.	1. a. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes. b. These responses can be innate and/or learned. c. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change.
2. understands most multicellular animals have nervous systems that underlie behavior.	2. a. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. b. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. c. Sense organs, specialized cells that detect light, sound, touch and specific chemicals, enable animals to monitor what is going on in the world around them.
3. understands behaviors are often adaptive when viewed in terms of survival and reproductive success.	3. a. Common behaviors include seeking food, seeking mates, raising young, avoiding predators, and regulating body temperature. b. Some organisms live in groups and have social behaviors that benefit both the individual and the group.

Teacher Notes:

The life science standards provide a framework for a variety of courses in the life sciences. These indicators may be included in local curriculum for any life sciences course, and are key concepts for a course focusing on human anatomy and physiology. Human anatomy, physiology and health are vital topics for students to understand. See Kansas Health and PE Standards for additional information.

▲ = High School Assessed Indicator

STANDARD 3: LIFE SCIENCE **Grades 8-12**

LIFE SCIENCE – The student will develop an understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems, and the behavior of organisms.

Benchmark 7: **The student will demonstrate an understanding of the diversity of structure and function in organisms.**

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands differences in structure and function among organisms and can identify the characteristics of relevant life forms.	1. a. Major structural differences among organisms include unicellular and multicellular, plants and animals, and invertebrates and vertebrates b. Common functions include digestion, respiration, excretion, locomotion, communication and reproduction
2. ▲understands that homeostasis is the dynamic regulation and balance of an organisms internal environment to maintain conditions suitable for survival.	
3. ▲understands that living things change following a specific pattern of developmental stages called life cycles.	
4. understands that in complex organisms there is a division of labor into specific body systems i.e., respiration, digestion, nervous, endocrine, excretion, circulatory, reproductive, immune, skeletal and muscle.	4. a. These systems interact with one another to maintain homeostasis. b. Relate the organs and their functions to the body system.

5. understands taxonomy is the systematic way in which organism are placed into a hierarchical classification system, according to their physical and genetic characteristics and their evolutionary history.	5. a. All organisms are classified into one of a number of kingdoms, the broadest taxonomic category b. All organisms are classified into a number of intermediate categories, of which species is the most specific.

Teacher notes:

The life science standards provide a framework for a variety of courses in the life sciences. These indicators may be included in local curriculum for any life sciences course, and are key concepts for a course focusing on human anatomy and physiology. Human anatomy, physiology and health are vital topics for students to understand. See Kansas Health and PE Standards for additional information.

▲ = High School Assessed Indicator

EARTH AND SPACE SCIENCE – The student will develop an understanding of energy in the earth system, geochemical cycles, the formation and organization of the earth system, the dynamics of the earth/moon/sun system, and the organization and development of the universe.

Benchmark 1: The student will develop an understanding of the sources of energy that power the subsystems and cycles of the dynamic earth: the geosphere, hydrosphere, atmosphere and biosphere.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands constructive and destructive processes, including weathering, erosion and deposition, dynamically reshape the surface of the earth.	1. a. The rock cycle describes constructive and destructive processes that change the forms of rocks and soil (solid earth). b. Water, glaciers, winds, waves, and gravity are weathering and erosion agents.
2. ▲ understands the theory of Plate Tectonics explains that internal energy drives the earth's ever changing structure.	2. a. Movable continental and oceanic plates make up earth's surface; the hot, convecting mantle is the energy source for plate movement. b. Essentially all energy on earth originates with the sun, is generated by radioactive decay in earth's interior, or is left over from earth's formation. c. Convection circulation in the mantle is driven by the outward transfer of earth's internal heat. d. Systems on earth's surface are powered principally by the sun and contain an essentially fixed amount of each stable chemical atom or element. e. Rocks, water, CO_2/ O_2, carbon and other nutrients cycle through different forms as a result of cycle biological and geologic processes.

3. The ultimate source of atmospheric and oceanic energy comes from the sun. Energy flow drives global climate and weather. Climate and weather are influenced by geographic features, cloud cover, and the earth's rotation.	3 . a. Energy from the sun heats the oceans and the atmosphere, and drives oceanic and atmospheric circulation. b. Human activity impacts global climate. Example: Burning of fossil fuels produces ground level ozone that hinders plant growth. c. The composition and structure of earth's atmosphere is a factor in the earth's suitability to support life. d. Weather patterns and seasonal weather change are multi-variable phenomena. e. Biogeochemical cycles are an example of the integration of earth, physical, and biological science concepts. f. Weather in the troposphere redistributes water on the surface of the earth through the water cycle. g. The ozone layer in the upper stratosphere filters UV radiation which is harmful to living things. h. Gamma radiation and other high energy radiation from the sun is filtered by the upper atmosphere. i. Concepts and skills include basic weather forecasting, weather maps, fronts, pressure systems, severe storms and safety precautions.

4. Understands the processes of water cycling through surface water (oceans, lakes, streams, glaciers), ground water (aquifers), and the atmosphere. (hydrological cycle)	4. a. Processes of evaporation, condensation, precipitation, transpiration, runoff, and filtration move water through the water cycle. b. Weather in the troposphere redistributes water on the surface of the earth through the water cycle. c. Ground water is stored in aquifers and moved through underground streams. d. Water in the atmosphere is in the form of water vapor and clouds.

Teacher Notes:

The concepts of energy in earth's dynamic subsystems and cycles are concepts that integrate earth/space, physical and biological sciences. These concepts may be a part of local curriculum in courses other than Earth/Space Science. Astronomy (Space Science) indicators related to light and forces can be addressed in physics and physical science courses.

Learning Science in the Outdoors: Varied experiences in the outdoors make natural processes less abstract and are critical to developing scientific literacy. Teachers are encouraged to create outdoor learning experiences for their students.

▲ = High School Assessed Indicator

EARTH AND SPACE SCIENCE – The student will develop an understanding of energy in the earth system, geochemical cycles, the formation and organization of the earth system, the dynamics of the earth/moon/sun system, and the organization and development of the universe.

Benchmark 2: The student will develop an understanding of the origin and development of the dynamic earth system.

Grades 8-12 Indicators	Additional Specificity
The student … 1. ▲ understands geological time is used to understand the earth's past.	1. a. Radioactive dating and relative dating (i.e. stratigraphy, fossils) are used to estimate the time rocks were formed. b. Earth changes can be short term (during a human's lifetime), such as earthquakes and volcanic eruptions, or long term (over a geological time scale), such as mountain building and plate movements. c. The earth's atmosphere has changed over time. For example: The dramatic changes in earth's atmosphere (i.e. introduction of O_2) which were affected by the emergence of life on earth. d. Relates geologic evidence to a record of earth's history e. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent.
Teacher Notes: The concepts of energy in earth's dynamic subsystems and cycles are concepts that integrate earth/space, physical and biological sciences. These concepts may be a part of local curriculum in courses other than Earth/Space Science. Astronomy (Space Science) indicators related to light and forces can be addressed in physics and physical science courses. ▲ = High School Assessed Indicator	

EARTH AND SPACE SCIENCE – The student will develop an understanding of energy in the earth system, geochemical cycles, the formation and organization of the earth system, the dynamics of the earth/moon/sun system, and the organization and development of the universe.

Benchmark 3: The student will develop an understanding of dynamics of our solar system.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands gravitational attraction of objects in the solar system keeps solar system objects in orbit.	1. a. Kepler's laws describe planetary motion. b. Newton's laws of inertia and gravity explain orbital motion. c. Because of the sun's large mass, the sun is the primary gravitational force in the solar system.
2. ▲ understands the relationship between the earth, moon, and sun explains the seasons, tides and moon phases.	2. a. The angle of incidence of solar energy striking earth's surface effect the amount of heat energy absorbed at earth's surface. b. The gravitational relationship between the earth, moon, and sun causes tides.
3. understands the relative sizes and distances of objects in the solar system.	
4. understands the sun, earth, and other objects in the solar system formed from a nebular cloud of dust and gas.	
Teacher Notes: The concepts of energy in earth's dynamic subsystems and cycles are concepts that integrate earth/space, physical and biological sciences. These concepts may be a part of local curriculum in courses other than Earth/Space Science. Astronomy (Space Science) indicators related to light and forces can be addressed in physics and physical science courses. ▲ = High School Assessed Indicator	

EARTH AND SPACE SCIENCE – The student will develop an understanding of energy in the earth system, geochemical cycles, the formation and organization of the earth system, the dynamics of the earth/moon/sun system, and the organization and development of the universe.

Benchmark 4: The student will develop an understanding of the organization of the universe, and its development

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲understands stellar evolution.	1. a. Condensation of gases, due to gravity, is a foundation for the formation of stars b. The life cycle of the star begins with the nebula, which contains mostly hydrogen and helium. Heavier elements were, and continue to be, made by the nuclear fusion reactions in stars. c. The Hertzsprung-Russell (H-R) diagram is used to classify stars. The sun is a main sequence star. d. Stars are classified by their color, temperature, age, apparent brightness and distance from earth.
2. understands the current scientific explanation of the origin and structure of the universe.	2. a. The formation of the universe began with an expansion of gases from a hot, dense state. By studying the light emitted from distant galaxies, it has been found that galaxies are moving apart from one another. b. The red shift of light, within the Doppler effect, emitted by distance galaxies supports the conclusion that the universe is expanding.
3. understand how the tools of astronomy have revolutionized the study of the universe.	c. Galaxies are a level of organization of the universe. There are at least 100 billion galaxies in the observable universe. Galaxies are organized into superclusters with large voids between them. d. The sun is a second-generation star, which, along with our galaxy (The Milky Way which includes about 100 billion stars) formed billions of years after the Big Bang.

	3. a. Current telescopes can measure across the Electromagnetic-Spectrum. b. Spectral analysis is used to determine chemical composition and energy of stars. c. Relative mass of objects can be determined by observing motion of objects in space and the effect one object's gravity has on another. d. The tools and skills of astronomers have changed through time: ancient astronomy (Stonehenge, Greeks, Chinese, Aristotle) through modern astronomy (Copernicus to present). e. Astronomical tools and skills allow astronomers to research phenomena and objects that cannot be observed and measured directly.

Teacher Notes:

The concepts of energy in earth's dynamic subsystems and cycles are concepts that integrate earth/space, physical and biological sciences. These concepts may be a part of local curriculum in courses other than Earth/Space Science. Astronomy (Space Science) indicators related to light and forces can be addressed in physics and physical science courses.

▲ = High School Assessed Indicator

STANDARD 5: SCIENCE AND TECHNOLOGY **Grades 8-12**

SCIENCE AND TECHNOLOGY – The student will develop understandings about the relationship between science and technology.

Benchmark 1: The student will develop an understanding that technology is applied science.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands technology is the application of scientific knowledge for functional purposes.	1. a. Technology is driven by the need to meet human needs and solve human problems. b. Engineering is the practical application of science to commerce or industry. c. Medicine is a practical application of science to human health. d. All technological advances contain a potential for both gains and risks for society.
2. understands creativity, imagination, and a broad scientific knowledge base are required to produce useful results.	
3. understands science advances new technologies. New technologies open new areas for scientific inquiry.	3. a. Technological knowledge may be kept confidential because of the commercial or military potential of the idea or invention. b. Invention which produces a new device, method or process is developed from study and experimentation often utilizing technology.
Teacher Notes: ▲ = High School Assessed Indicator	

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global settings.

Benchmark 1: The student will develop an understanding of the overall functioning of human systems and their interaction with the environment in order to understand specific mechanisms and processes related to health issues.

Grades 8-12 Indicators	Additional Specificity
The student … 1. understands some chemical and physical hazards and accidents can be avoided through safety education 2. understands the severity of disease symptoms is dependent on many factors, 3. understands informed personal choices concerning fitness and health involve an understanding of chemistry and biology. 4. understands selection of foods and eating patterns determine nutritional balance which affects emotional and physical well-being.	2. a. These factors include age, genetic predisposition, nutrition, and environmental factors. b. Many diseases can be prevented, controlled, or cured. Some diseases are communicable and some are not.
Teacher Notes: See Kansas Health and PE Standards for additional guidance for health education. ▲ = High School Assessed Indicator	

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global settings.

Benchmark 2: The student will demonstrate an understanding of population growth.

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Grades 8-12 Indicators	Additional Specificity
The student … 1. understands the rate of change in populations is determined by the combined effects of birth, death, emigration, and immigration. 2. understands a variety of factors influence birth rates and fertility rates. 3. understands populations have limits to growth.	1. Populations can increase through exponential growth. 2. Population growth changes resource availability and changes environmental conditions.
Teacher Notes: ▲ = High School Assessed Indicator	

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global settings.

Benchmark 3: The student will understand that human populations use natural resources and influence environmental quality.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. ▲ understands natural resources from the lithosphere and ecosystems are required to sustain human populations.	1. a. These processes of ecosystems include maintenance of the atmosphere, generation of soils, control of the hydrologic cycle, and recycling of nutrients. Humans are altering many of these processes, and the changes may be detrimental, beneficial, or both to ecosystem function. b. Natural systems can reuse waste, but this capacity is limited. Recycling and environmentally sound decisions improve the quality of human life.
2. understands earth does not have infinite resources.	2. a. Increasing human consumption places stress on most renewable resources and depletes non-renewable resources. b. Carrying capacity is the maximum number of organisms that can be sustained in a given environment. Natural resources limit the capacity of ecosystems to sustain populations.

Teacher Notes:
Learning Science in the Outdoors: Varied experiences in the outdoors make natural processes less abstract and are critical to developing scientific literacy. Teachers are encouraged to create outdoor learning experiences for their students.

▲ = High School Assessed Indicator

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES **Grades 8-12**

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global settings.

Benchmark 4: The student will understand the effect of natural and human-influenced hazards.

Grades 8-12 Indicators	Additional Specificity
The student …	The student …
1 understands natural processes of earth may be hazardous for humans.	1. Humans live at the interface between two dynamically changing systems, the atmosphere and earth's crust. Human beings need to make informed choices about potential disruption by natural processes (such as volcanic activity, earthquake zones, severe weather, flood plains, …)
2. understands there is a need to assess potential risk and danger from natural and human-induced hazards.	2. Human-initiated changes in the environment bring benefits as well as risks to society. Various changes have costs and benefits. For example, vaccinations are a benefit for our society but can have risks for individuals.
Teacher Notes:	

SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES – The student will develop an understanding of personal and community health, population growth, natural resources, environmental quality, natural and human-induced hazards, and science and technology in local, national, and global settings.

Benchmark 5: The student will develop an understanding of the relationship between science, technology, and society.

Grades 8-12 Indicators	Additional Specificity
The student … 1. understands progress in science and technology can be affected by social issues and challenges. Science and technology indicate what can happen, not what should happen.	1. Increased use of antibiotics may also increase human resistance to antibiotics.
Teacher Notes: ▲ = High School Assessed Indicator	

HISTORY AND NATURE OF SCIENCE – The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 1: The student will develop an understanding that science is a human endeavor that uses models to describe and explain the physical universe.

Grades 8-12 Indicators	Additional Details
The student…	
1. demonstrates an understanding of science as both vocation and avocation.	
2. explains how science uses peer review, replication of methods, and norms of honesty.	2. Scientific knowledge is made public through presentations at professional meetings and publications in scientific journals.
3. recognizes the universality of basic science concepts and the influence of personal and cultural beliefs that embed science in society.	
4. recognizes that society helps create the ways of thinking (mindsets) required for scientific advances, both toward training scientists and educating a populace to utilize benefits of science (e.g., standards of hygiene, attitudes toward forces of nature, etc.).	
5. understands there are many issues which involve morals, ethics, values or spiritual beliefs that go beyond what science can explain, but for which solid scientific literacy is useful.	5. Common examples involve bioethics, environmental issues, and military applications.
6. recognizes society's role in supporting topics of research and determining institutions where research is conducted.	
Teacher Notes: ▲ = High School Assessed Indicator	

HISTORY AND NATURE OF SCIENCE – The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 2: The student will develop an understanding of the nature of scientific knowledge.

Grades 8-12 Indicators	Additional Specificity
The student …	
1. understands scientific knowledge describes and explains the physical world in terms of matter, energy, and forces. Scientific knowledge is provisional and is subject to change as new evidence becomes available.	1. a. Additional evidence can lead to further confirmation, revision and refinement, or rejection of previously accepted explanations. b. The core theories of science have a high degree of reliability within the limits to which they have been tested and their scope of applicability. c. The open-endedness of science is its greatest strength and allows for constant refining and improvement of our explanations.
2. understands scientific knowledge begins with empirical observations, which are the data (also called facts or evidence) upon which further scientific knowledge is built.	2. a. The breadth and depth of sensory observations are enhanced by technological instruments such as microscopes, telescopes, and oscilloscopes. b. Observations often include measurements, to varying degrees of accuracy and precision, so they can be described and analyzed with mathematics. c. Observational data is gathered in a number of ways, including controlled experiments, field studies, and the systematic observation of natural phenomena.

3. understands scientific knowledge consists of hypotheses, inferences, laws, and theories.	3. a. A hypothesis is a testable statement that is subject to further investigation and potential confirmation b. An inference is a testable conclusion, based on previously established knowledge, observed evidence, and logic. c. A law is a thoroughly tested descriptive generalization of a highly regular phenomenon, usually expressed in mathematical form. d. A theory is a broad explanation that integrates a wide range of observations and tested hypotheses, inferences, and laws (when applicable) into a meaningful and coherent whole. e. Well established and widely accepted explanations have explanatory and predictive power and are fruitful as guides for further research.
4. understands a testable hypothesis or inference must be subject to confirmation by empirical evidence	4. a. A valid hypothesis or inference must be potentially falsifiable. b. A hypothesis or inference is tested by making logical predictions about what observational data one would expect to exist, given the hypothesis, and then comparing actual observed data to the predicted data, which will either support or not support the hypothesis.
Teacher Notes: ▲ = High School Assessed Indicator	

HISTORY AND NATURE OF SCIENCE – The student will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 3: The student will understand science from historical perspectives.

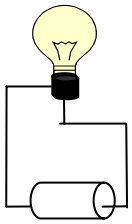
Grades 8-12 Indicators	Additional Specificity
The student…	
1. demonstrates an understanding of the history of science.	1. a. Modern science has been a successful enterprise that contributes to dramatic improvements in the human condition. b. Science progresses by incremental advances of scientists or teams of scientists. c. Some advances that are fundamental and long-lasting include: Copernican revolution, Newtonian physics, relativity, geological time scale, plate tectonics, atomic theory, nuclear physics, biological evolution, germ theory, industrial revolution, molecular biology, quantum theory, and medical and health technology.
2. demonstrates a knowledge that scientific method historically proceeded from an inductive approach rather than a deductive approach.	2. a. With the deductive method, scientists start with axioms - simple true statements about the way the world works. Galileo and his contemporaries realized that, for science, the problem was that it was enormously difficult to begin with "simple true statements about the way the world works". In fact, they realized that the simple true statement should be the goal of science, not the starting place. Since the 1600s to the mid 1900s, the inductive method has been incredibly successful in investigating nature.
Teacher Notes: ▲ = High School Assessed Indicator	

Glossary

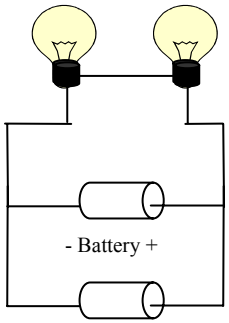
This glossary in not intended as a comprehensive glossary of science terms or science education terms. Words defined here are a complied list of terms that are defined in grade level Teacher Notes within the Kansas Science Education Standards. After each term, the grade level where the definition is applied is KSES is noted.

Circuits (KSES Gr. K-4)

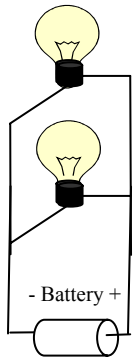
Simple circuit – include diagram



Series circuit –include diagram



Parallel circuit - - include diagram



Classify – a method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change; the test for good classification system is whether others can use it. (KSES Gr. K-4)

Current is the rate at which charges are flowing in a circuit. (KSES Gr. K-4)

Environment – all external conditions and factors, living and non-living, that affect an organism during its life time. (KSES Gr. K-4)

Full inquiry – involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. In elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry. They can design investigations to try things to see what happens – they tend to focus on concrete results of tests and will entertain the idea of a "fair" test (a test in which only one variable at a time is changed) (see page 122 in the National Science Education Standards, 1996). (KSES Gr. K-4)

Earth materials - rocks, soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties which make them useful in different ways. (KSES Gr. K-4)
Fossil - is a part of a once-living organism or a trace of an organism preserved in rock. (KSES Gr. K-4)

Erosion – movement of earth materials from one place to another. (KSES Gr. K-4)
Interact- when two or more things do something to each other. (KSES Gr. K-4)

Investigation – finding the answer to a question. (KSES Gr. K-4)

Life cycle – the process by which organisms mature, reproduce, and die. (KSES Gr. K-4)

Mass - measure of the amount of material something contains. (KSES Gr. K-4)

Organisms – any form of life. (KSES Gr. K-4)

Properties – a word that describes an object based on direct observations using touch, sight, hearing, taste, smell, and measurement. (KSES Gr. K-4)

Scientific investigation – A scientific investigation uses scientific inquiry to ask an answer a question. (KSES Grades 5-7)

Scientific inquiry – The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative (scientific) explanations. Students will engage in selected aspects of inquiry (partial or guided inquiry) as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete investigations (full inquiry). (From the National Education Standards, p. 23) (KSES Gr. 5-7)

Technology - Creates products to meet human needs by applying scientific principles. Science and technology are reciprocal. Science helps drive technology. Technology is essential to science, because it provides instruments and techniques that promote scientific inquiry. (KSES Grades 5-7)

Structures – parts of the organism that serve different functions in growth, survival, and reproduction. (KSES Gr. K-4)

Technology – application of knowledge through inventions. (see 8-12 Standard 5 document)

Tools – object used to achieve a goal, to make an observation, and extend the senses (see page 122 in the National Science Education Standards, 1996). (KSES Gr. K-4)

Weight – The response of mass to the pull of gravity. Weight is a measure of force. Note: Weight is often confused with mass. Mass is the amount matter (stuff) an object has and is not dependent on the object's location. Weight is a measure of force and is not constant because the pull of gravity on an object's mass varies with location. An object would weight less on Earth than on Jupiter because Jupiter has greater mass than Earth; Jupiter's mass would have a greater gravitational attraction for the object. (KSES Gr. 5-7)

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Appendix I

K-4 Grade-by-Grade Kansas Science Standards

The Kansas State Science Education Standards include standards, benchmarks, indicators, and examples which are designed to assist Kansas educators in selecting and developing local curricula, carrying out instructions, and assessing students' progress. They will also serve as the foundation for the development of state assessments in science. These standards, benchmarks, indicators, and examples represent high, yet reasonable expectations for all students.
The Kansas State Science Education Standards:

- Bring coordination, consistency, and coherence to the improvement of science education in Kansas.

- *Advocate* **that science education must be developmentally appropriate and reflect a systematic, progressive approach throughout the elementary, middle, and high school years.**
- Are not intended to be viewed as a state curriculum or instructional strategy. The content embodied in the standards can be organized and presented with many different emphases and perspectives in local district curricula.

Purpose of this Document
This document is one example of a breakdown of indicators into grade levels. This particular breakdown is not intended to be the only organizational option but give developmentally appropriate guidance in designing local curricula.

There are two different versions of the same indicator breakdown. The first is simply a list of indicators. The second style is the same information with more supporting documentation.

A suggested vocabulary list has been included to give guidance as to vocabulary that is necessary for achieving proficiency on the state assessment and to help develop a scientific literate society. This list was developed using state standards and test specifications.

Kindergarten Recommendations

(Derived from K-2 Standards Document)

Science	
1.1.1	The student identifies properties of objects
1.1.5	describes an observation orally or pictorially.
2.1.2	separates or sorts a group of objects or materials by properties.
3.1.4	examines the structures/parts of living things.
4.2.1	observes and recognizes the sun, moon, stars, clouds, birds, airplanes and other objects in the sky.
4.2.2	describes that the sun provides light and warmth.
4.3.1	observes changes in the weather from day to day.
4.3.3	discusses weather safety procedures.
5.1.1	explores the way things work.
6.1.1	engages in personal care.
6.1.2	discusses healthy foods.
6.1.3	discusses that humans need to practice being safe.
7.1.1	is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
7.1.2	uses technology to learn about people in science.

K-2 Common Vocabulary	Kindergarten Vocabulary
describe	airplanes
explore	birds
objects	clouds
observe	health
organism	light
properties	material
safety	moon
scientist	personal care
structure	safety
weather	sky
predict	sort
graph	stars
nutrition	sun
texture	warmth

1st Grade Recommendations

(Derived from K-2 Standards Document)

Science	
1.1.2	The student classifies and arranges groups of objects by a variety of properties, one property at a time.
1.1.5	describes an observation orally or pictorially.
2.1.3	compares the properties of solids and liquids.
2.1.4	describes the position of an object in relation to other objects.
3.1.1	discusses that organisms live only in environments in which their needs can be met.
3.1.3	observes living things in various environments
3.1.4	examines the structures/parts of living things.
4.1.1	observes, compares, and sorts earth materials.
4.3.3	discusses weather safety procedures.
5.1.1	explores the way things work.
6.1.1	engages in personal care.
6.1.2	discusses healthy foods.
6.1.3	discusses that humans need to practice being safe.
7.1.1	is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
7.1.2	uses technology to learn about people in science.

K-2 Common Vocabulary	1st grade Vocabulary
describe	basic needs
explore	classify (sort)
objects	compare
observe	earth materials
organism	examine
properties	liquid
safety	personal care
scientist	safety
structure	solid
weather	habitat
Predict	
Graph	
Nutrition	
texture	

2nd Grade Recommendations

(Derived from K-2 Standards Document)

Science	
1.1.3	The student uses appropriate materials, tools, and safety procedures to collect information.
1.1.4	asks and answers questions about objects, organisms, and events in his/her environment.
1.1.5	describes an observation orally or pictorially.
2.1.1	observes properties of objects and measures or describes those properties using age-appropriate tools and materials.
3.1.2	observes life cycles of different living things.
3.1.4	examines the structures/parts of living things.
4.3.2	records weather changes daily.
4.3.3	discusses weather safety procedures.
5.1.2	experiences science through technology.
6.1.1	engages in personal care.
6.1.2	discusses healthy foods.
6.1.3	discusses that humans need to practice being safe.
7.1.1	Is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
7.1.2	uses technology to learn about people in science.

K-2 Common Vocabulary	2nd Grade Vocabulary
describe	events
explore	health
objects	life cycle
observe	measure
organism	safety
properties	tool
safety	habitat
scientist	thermometer
structure	magnifiers
weather	balances
predict	scales
graph	measuring cups
nutrition	measuring spoons
texture	

3rd Grade Recommendations

(Derived from 3-4 Standards Document)

Science	
1.1.1	▲ The student asks questions that he/she can answer by investigating.
1.1.2	▲ plans and conducts a simple investigation.
1.1.3	▲employs appropriate equipment, tools, and safety procedures to gather data.
1.1.4	▲begins developing the abilities to communicate, critique, analyze his/her own investigations, and interprets the work of other students.
2.1.2	▲describes and classifies objects by more than one property.
2.1.3	▲observes and records how one object interacts with another object.
2.1.4	▲recognizes and describes the differences between solids, liquids, and gases
2.2.1	▲moves objects by pushing, pulling, throwing, spinning, dropping, and rolling; and describes the motion.
2.2.2	describes the change in position of objects when moved.
2.4.1	▲demonstrates that magnets attract and repel.
3.1.1	▲observes different organisms and compares and contrasts how similar functions are served by different structural characteristics.
3.1.2	▲compares basic needs of different organisms in their environment.
3.1.3	discusses ways organisms use their senses to survive in their environments.
4.1.1	▲ collects, observes properties, and classifies a variety of earth materials in his/her environment.
4.1.2	experiments with a variety of soil types (clay, silt, sand, and loam)
4.2.1	observes the moon and stars.
4.2.2	observes and compares the length of shadows.
4.2.3	▲discusses that the sun provides light and heat (electromagnetic radiation) to maintain the temperature of earth.
5.1.1	▲identifies a simple design problem (designs a plan, implements a plan, evaluates the results, makes changes to improve the product, and communicates the results.)
5.2.1	will understand that the design process produces knowledge that can be used to solve a problem and improve our world.
5.2.2	invents a product to solve problems.
5.2.3	works with others to solve problems.
5.2.5	investigates how scientists use tools to observe.
6.1.1	▲discusses the nutritional value of various foods and their contribution to health.
6.1.2	discusses that safety involves preventing injury by avoiding inappropriate risks and dangers.
6.1.3	assumes some responsibility for his/her own health, and the health and well being of others.
6.2.1	defines pollution.
6.2.3	practices reducing, reusing, and recycling.
7.1.1	recognizes that students participate in science inquiry by asking questions. (ties in with 1.1.1)

Grades 3-4 Common Vocabulary	Grade 3 Content Vocabulary	Grade 3 Tested Vocabulary
Analyze	Clay	Analyze
Compare	Silt	Basic needs
Contrast	Sand	Characteristics
Evidence	Loam	Critique
Inquiry	Evaluate	Design
Interpret	Inquiry	Earth materials
Investigate	Invent	Environment
Observes	Pollution	Equipment
Organism	Reduce	Evaluate
Properties	Reuse	Function
Records	Recycle	Interpret
Technology	Soil	Magnets, attract, repel
Tools	Survive	Motion
Predict	humus	Nutritional value
Problem		Pushing, pulling, throwing
Procedure		Safety procedures
Graph		Solid, liquid, gas
Nutrition		Spinning, dropping
Texture		Rolling
Experiment		Structure
Risk		Poles
Injury		Habitat
hygiene		Hand lens
		Meter stick
		Tape measure
		Measuring cups
		Balance
		Thermometer
		Spring scale
		Graduated cylinder
		Dropper
		stopwatch

4th Grade Recommendations

(Derived from 3-4 Standards Document)

Science	
1.1.1	▲ The student asks questions that he/she can answer by investigating.
1.1.2	▲ plans and conducts a simple investigation.
1.1.3	▲employs appropriate equipment, tools, and safety procedures to gather data.
1.1.4	▲ begins developing the abilities to communicate, critique, analyze his/her own investigations, and interprets the work of other students.
2.1.1	▲observes properties of objects and measures those properties using appropriate tools.
2.1.3	▲observes and records how one object interacts with another object.
2.3.1	▲identifies that the source of sound is vibrations.
2.3.2	discriminates between sounds made by different objects.
2.3.3	discriminates between various pitches.
2.4.2	▲designs a simple experiment to determine whether various objects will be attracted to magnets.
2.4.3	▲constructs a simple circuit.
3.2.1	▲compares, contrasts, and asks questions about life cycles of various organisms.
4.1.3	▲describes properties of water and the process of the water cycle.
4.1.4	observes and records the properties of fossils and discusses what fossils are.
4.3.1	▲describes changes in the surface of the earth.
4.3.2	▲observes, describes, and records daily and seasonal weather changes.
5.1.1	▲identifies a simple design problem (designs a plan, implements the plan, evaluates the results, makes changes to improve the product, and communicates the results.)
5.2.1	will understand that the design process produces knowledge that can be used to solve a problem and improve our world.
5.2.4	develops an awareness that women and men of all ages, backgrounds, and ethnic groups engage in a variety of scientific and technological work.
6.1.1	▲discusses the nutritional value of various foods and their contribution to health.
6.1.2	discusses that safety involves preventing injury by avoiding inappropriate risks and dangers.
6.1.3	assumes some responsibility for his/her own health, and the health and well being of others.
6.2.2	develops personal actions to solve pollution problems in and around the neighborhood.
7.1.2	studies the lives of people who made scientific contributions.

Grades 3-4 Common Vocabulary	Grade 4 Content Vocabulary	Grade 4 Tested Vocabulary
Analyze	Communicate	Equipment
Compare	Fossils	Erosion
Contrast	Interact	Evaluate
Evidence	Pitch	Implement
Inquiry	Pollution	Interact
Interpret	Safety	Safety procedures
Investigate	Weather	Simple circuit
Observes	Records	Sound
Organism	Technology	Vibration
Properties	Tools	Water cycle
Predict	Volume	Design problem
Problem		Simple parallel circuit
Procedure		Simple series circuit
Graph		Conduct electricity
Thermometer		Metamorphosis
Nutrition		Complete circuit
Texture		Design problem
Energy		Hand lens
Habitat		Meter stick
Experiment		Tape measure
Risk		Measuring cup
Injury		Balance
Hygiene		Thermometer
		Spring scale
		Graduated cylinder
		Dropper
		Stopwatch

Kindergarten

STANDARD 1: SCIENCE AS INQUIRY

The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will be involved in activities that develop skills necessary to conduct scientific inquiries.

1. The student identifies properties of objects.

5. The student describes an observation orally or pictorially.

STANDARD 2: PHYSICAL SCIENCE

The students will explore the world by observing and manipulating common objects and materials in their environment.

Benchmark 1: All students will develop skills to describe objects.

2. The student separates or sorts a group of objects or materials by properties.

STANDARD 3: LIFE SCIENCE

The student will begin to develop an understanding of biological concepts.

Benchmark 1: The student will develop an understanding of the characteristics of living things.

4. The student examines the structures/parts of living things.

STANDARD 4: EARTH AND SPACE SCIENCE

The student will observe closely the objects and materials in their *environment*.

Benchmark 2: The student will observe and compare objects in the sky.

1. The student observes and recognizes the sun, moon, stars, clouds, birds, airplanes, and other objects in the sky.

2. The student describes that the sun provides light and warmth.

Benchmark 3: The student will describe changes in weather.

1. The student observes changes in the weather from day to day.

3. The student discusses weather safety procedures.

STANDARD 5: SCIENCE AND TECHNOLOGY

The student will have a variety of educational experiences that involve science and *technology*.

Benchmark 1: The student will use technology to learn about the world around them.

1. The student explores the way things work.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

The student will have a variety of experiences that provide understandings for various science-related personal and environmental challenges.

Benchmark 1: The student will demonstrate responsibility for their own health.

1. The student engages in personal care.
2. The student discusses healthy foods.
3. The student discusses that humans need to practice being safe.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

The student will experience scientific inquiry and learn about people from history.

Benchmark 1: The student will know they practice science.

1. The student is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
2. The student uses technology to learn about people in science.

Grade 1

STANDARD 1: SCIENCE AS INQUIRY

The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will be involved in activities that develop skills necessary to conduct scientific inquiries.

2. The student classifies and arranges groups of objects by a variety of properties, one property at a time.

5. The student describes an observation orally or pictorially.

STANDARD 2: PHYSICAL SCIENCE

The students will explore the world by observing and manipulating common objects and materials in their environment.

Benchmark 1: All students will develop skills to describe objects.

3. The student compares solids and liquids.

4. The student describes the position of an object in relation to other objects.

STANDARD 3: LIFE SCIENCE

The student will begin to develop an understanding of biological concepts.

Benchmark 1: The student will develop an understanding of the characteristics of living things.

1. The student discusses that organisms live only in environments in which their needs can be met.

3. The student observes living things in various environments.

4. The student examines the structures/parts of living things.

STANDARD 4: EARTH AND SPACE SCIENCE

The student will observe closely the objects and materials in their *environment*.

Benchmark 1: The student will describe properties of earth materials.

1. The student observes, compares, and sorts earth materials.

Benchmark 3: The student will describe changes in weather.

3. The student discusses weather safety procedures.

STANDARD 5: SCIENCE AND TECHNOLOGY

The student will have a variety of educational experiences that involve science and *technology*.

Benchmark 1: The student will use technology to learn about the world around them.

1. The student explores the way things work.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

The student will have a variety of experiences that provide understandings for various science-related personal and environmental challenges.

Benchmark 1: The student will demonstrate responsibility for their own health.

1. The student engages in personal care.
2. The student discusses healthy foods.
3. The student discusses that humans need to practice being safe.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

The student will experience scientific inquiry and learn about people from history.

Benchmark 1: The student will know they practice science.

1. The student is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
2. The student uses technology to learn about people in science.

Grade 2

STANDARD 1: SCIENCE AS INQUIRY

The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will be involved in activities that develop skills necessary to conduct scientific inquiries.

3. The student uses appropriate materials, tools, and safety procedures to collect information.

4. The student asks and answers questions about objects, organisms, and events in his/her environment.

5. The student describes an observation orally or pictorially.

STANDARD 2: PHYSICAL SCIENCE

The students will explore the world by observing and manipulating common objects and materials in their environment.

Benchmark 1: All students will develop skills to describe objects.

1. The student observes properties of objects and measures or describes those properties using age-appropriate tools and materials.

STANDARD 3: LIFE SCIENCE

The student will begin to develop an understanding of biological concepts.

Benchmark 1: The student will develop an understanding of the characteristics of living things.

2. The student observes life cycles of different living things.

4. The student examines the structures/parts of living things.

STANDARD 4: EARTH AND SPACE SCIENCE

The student will observe closely the objects and materials in their *environment*.

Benchmark 3: The student will describe changes in weather.

2. The student records weather changes daily.

3. The student discusses weather safety procedures.

STANDARD 5: SCIENCE AND TECHNOLOGY

The student will have a variety of educational experiences that involve science and *technology*.

Benchmark 1: The student will use technology to learn about the world around them.

2. The student experiences science through technology.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

The student will have a variety of experiences that provide understandings for various science-related personal and environmental challenges.

Benchmark 1: The student will demonstrate responsibility for their own health.

1. The student engages in personal care.
2. The student discusses healthy foods.
3. The student discusses that humans need to practice being safe.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

The student will experience scientific inquiry and learn about people from history.

Benchmark 1: The student will know they practice science.

1. The student is involved in explorations that make his/her mind wonder and know that he/she is practicing science.
2. The student uses technology to learn about people in science.

Grade 3

STANDARD 1: SCIENCE AS INQUIRY

The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will develop the skills necessary to do full inquiry. *Full inquiry* involves asking a simple question, completing an *investigation*, answering the question, and sharing the results with others.

1. ▲The student asks questions that he/she can answer by investigating.

2. ▲The student plans and conducts a simple investigation.

3. ▲The student employs appropriate equipment, tools, and safety procedures to gather data.

4. ▲The student begins developing the abilities to communicate, critique, analyze his/her own investigations, and interprets the work of other students.

STANDARD 2: PHYSICAL SCIENCE

The student will increase their understanding of the *properties* of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and *classify* these materials by observable properties.

Benchmark 1: The student will develop skills to describe objects.

2. ▲The student describes and classifies objects by more than one property.

3. ▲The student observes and records how one object interacts with another object.

4. ▲ The student recognizes and describes the differences between solids, liquids, and gases.

Benchmark 2: The student will describe the movement of objects.

1. ▲The student moves objects by pushing, pulling, throwing, spinning, dropping, and rolling; and describes the motion.

2. The student describes change in position of objects when moved.

Benchmark 4: The student will experiment with electricity and magnetism.

1. ▲The student demonstrates that magnets attract and repel.

STANDARD 3: LIFE SCIENCE

The student will develop an understanding of biological concepts through direct experience with living things, their life cycles, and their habitats.

Benchmark 1: The student will develop knowledge of organisms in their environment.

1. ▲The student observes different organisms and compares and contrasts how similar functions are served by different structural characteristics.

2. ▲The student compares basic needs of different organisms in their environment.

3. The student discusses ways organisms use their senses to survive in their environments.

STANDARD 4: EARTH AND SPACE SCIENCE

The student will observe objects, materials, and changes in their environment, note their properties, distinguish one from another, and develop their own explanations making sense of their observations.

Benchmark 1: The student will develop an understanding of the properties of *earth materials*.

1. ▲The student collects, observes properties, and classifies a variety of earth materials in his/her environment.

2. The student experiments with a variety of soils types (clay, silt, sand, and loam).

Benchmark 2: The student will observe and describe objects in the sky.

1. The student observes the moon and stars.

2. The student observes and compares the length of shadows.

3. ▲The student discusses that the sun provides light and heat (electromagnetic radiation) to maintain the temperature of the earth.

STANDARD 5: SCIENCE AND TECHNOLOGY

The student will have a variety of educational experiences which involve science and technology. The student will begin to understand the design process.

Benchmark 1: The student will work with a technology design.

1. ▲The student identifies a simple design problem (designs a plan, implements the plan, evaluates the results, makes changes to improve the product, and communicates the results).

Benchmark 2: The student will apply their understanding about science and technology.

1. The student will understand that the design process produces knowledge that

can be used to solve a problem and improve our world.

2. The student invents a product to solve problems.

3. The student works with others to solve problems.

5. The student investigates how scientists use tools to observe.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

The student will demonstrate personal health and environmental practices.

Benchmark 1: The student will develop an understanding of personal health.

1. ▲ The student discusses the nutritional value of various foods and their contribution to health.

2. The student discusses that safety involves preventing injury by avoiding inappropriate risks and dangers.

3. The student assumes some responsibility for his/her own health, and the health and well being of others.

Benchmark 2: The student will demonstrate an awareness of changes in the environment.

1. The student defines pollution.

3. The student practices reducing, reusing, and recycling.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

The student will experience some things about scientific inquiry and learn about people from history. Benchmark 1: The student will develop an awareness that people practice science.

1. The student recognizes that students participate in science inquiry by asking questions. (ties in with 1.1.1)

Grade 4

STANDARD 1: SCIENCE AS INQUIRY

The student will experience science as *full inquiry*. In the elementary grades, students begin to develop the physical and intellectual abilities of scientific inquiry.

Benchmark 1: The student will develop the skills necessary to do full inquiry. *Full inquiry* involves asking a simple question, completing an *investigation*, answering the question, and sharing the results with others.

1. ▲The student asks questions that he/she can answer by investigating.

2. ▲The student plans and conducts a simple investigation.

3. ▲The student employs appropriate equipment, tools, and safety procedures to gather data.

4. ▲The student begins developing the abilities to communicate, critique, analyze his/her own investigations, and interprets the work of other students.

STANDARD 2: PHYSICAL SCIENCE

The student will increase their understanding of the *properties* of objects and materials that they encounter on a daily basis. The student will compare, describe, and sort and *classify* these materials by observable properties.

Benchmark 1: The student will develop skills to describe objects.

1. ▲The student observes properties of objects and measures those properties using appropriate tools.

3. ▲The student observes and records how one object interacts with another object.

Benchmark 3: The student will recognize and demonstrate what makes sounds.

1. ▲The student identifies that the source of sound is vibrations.

2. The student discriminates between sounds made by different objects.

3. The student discriminates between various pitches

Benchmark 4: The student will experiment with electricity and magnetism.

2. ▲The student designs a simple experiment to determine whether various objects will be attracted to magnets.

3. ▲The student constructs a simple circuit.

STANDARD 3: LIFE SCIENCE

The student will develop an understanding of biological concepts through direct experience with living things, their life cycles, and their habitats.

Benchmark 2: The student will observe and illustrate the life cycles of various organisms.

1. ▲The student compares, contrasts, and asks questions about life cycles of various organisms.

STANDARD 4: EARTH AND SPACE SCIENCE

The student will observe objects, materials, and changes in their environment, note their properties, distinguish one from another, and develop their own explanations making sense of their observations.

Benchmark 1: The student will develop an understanding of the properties of *earth materials*.

3. ▲The student describes properties of water and the process of the water cycle.

4. The student observes and records the properties of fossils and discusses what fossils are.

Benchmark 3: The student will develop skills necessary to describe changes in the earth and weather.

1. ▲The student describes changes in the surface of the earth.

2. ▲The student observes, describes, and records daily and seasonal weather changes.

Standard 5: SCIENCE AND TECHNOLOGY

The student will have a variety of educational experiences which involve science and technology. The student will begin to understand the design process.

Benchmark 1: The student will work with a technology design.

1. ▲The student identifies a simple design problem (designs a plan, implements the plan, evaluates the results, makes changes to improve the product, and communicates the results).

Benchmark 2: The student will apply their understanding about science and technology.

1. The student will understand that the design process produces knowledge that can be used to solve a problem and improve our world.

4. The student develops an awareness that women and men of all ages, backgrounds, and ethnic groups engage in a variety of scientific and technological work.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

The student will demonstrate personal health and environmental practices.

Benchmark 1: The student will develop an understanding of personal health.

1. ▲The student discusses the nutritional value of various foods and their contribution to health.

2. The student discusses that safety involves preventing injury by avoiding inappropriate risk and dangers.

3. The student assumes some responsibility for his/her own health, and the health and well being of others.

Benchmark 2: The student will demonstrate an awareness of changes in the environment.

2. The student develops personal actions to solve pollution problems in and around the neighborhood.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

The student will experience some things about scientific inquiry and learn about people from history.

Benchmark 1: The student will develop an awareness that people practice science.

2. The student studies the lives of people who made scientific contributions.

Appendix II

5-7 Grade Level Assigned Indicators

Introduction

Two recommended formats for 5th, 6th, and 7th grade science indicator alignment are provided in this appendix. These formats incorporate all the Kansas State Science Standards and include: *Integrated and Standard-Specific* versions. These are only recommendations to help guide districts with curriculum alignment in science using the resources available to them.

In both formats, Standard 1 (Science as Inquiry), Standard 5 (Science and Technology), Standard 6 (Science in Personal and Environmental Perspectives), & Standard 7 (History and Nature of Science) should be taught at all grade levels. All standards, benchmarks, and indicators have been addressed in both formats.

The *integrated format* has assigned certain indicators to grade levels based on the difficulty of the indicator and other related indicators. The assigned indicators should be mastered in the assigned grade level as appropriate for the age group.

The *standard-specific format* has assigned a certain standard to a certain grade level. Fifth grade has been assigned Standard 4 (Earth and Space Science). Sixth grade has been assigned Standard 2 (Physical Science). Seventh grade has been assigned Standard 3 (Life Science).

These formats are solely recommendations. They may be changed to meet the needs of each individual district. This document is to be used in addition to the Kansas Curricular Standards for Science. They can be found on the Kansas State Department of Education website at: www.ksde.org (from the left bar select educators, standards, science).

For further assistance on each of the assessed indicators, please refer to the Science Test Items Specifications also located on the KSDE website (from the left bar select educators, assessments, science assessments, science test items specifications).

Summary of the Kansas Science Standards

STANDARD 1: SCIENCE AS INQUIRY
The student will develop the abilities to do *scientific inquiry*, be able to demonstrate how *scientific inquiry* is applied, and develop understandings about *scientific inquiry*.

STANDARD 2: PHYSICAL SCIENCE
The student will apply process skills to develop an understanding of physical science including: properties, changes of properties of matter, motion and forces, and transfer of energy.

STANDARD 3: LIFE SCIENCE
The student will apply process skills to explore and understand structure and function in living systems, reproduction and heredity, regulation and behavior, populations and ecosystems, and diversity and adaptations of organisms.

STANDARD 4: EARTH and SPACE SCIENCE
The student will apply process skills to explore and develop an understanding of the structure of the earth system, earth's history, and earth in the solar system.

STANDARD 5: SCIENCE AND TECHNOLOGY
The student will demonstrate abilities of technological design and understandings about science and technology.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES
The student will apply process skills to explore and develop an understanding of issues of personal health, population, resources and environment, and natural hazards.

STANDARD 7: HISTORY AND NATURE OF SCIENCE
The student will examine and develop an understanding of science as a historical human endeavor.

5th Grade Recommendations

Integrated	
2.1.1	▲ compares and classifies the states of matter; solids, liquids, gases, and plasma
2.2.2	▲ measures and graphs the effects of temperature on matter.
2.3.4	▲ investigates and explains how simple machines multiply force at the expense of distance.
2.4.1	understands the difference between potential and kinetic energy.
2.4.3	▲ observes and communicates how light (electromagnetic) energy interacts with matter: transmitted, reflected, refracted, and absorbed.
3.4.1	▲ recognizes that all populations living together (biotic resources) and the physical factors (abiotic resources) with which they interact compose an ecosystem.
3.4.2	understands how limiting factors determine the carrying capacity of an ecosystem.
3.4.3	▲ traces the energy flow from the sun (source of radiant energy) to producers (via photosynthesis – chemical energy) to consumers and decomposers in food webs.
4.3.1	▲ compares and contrasts the characteristics of stars, planets, moons, comets, and asteroids.
4.3.2	models spatial relationships of the earth/moon/planets/sun system to scale.
4.3.3	identifies past and present methods used to explore space.

5th Grade (Standard-Specific)

Standard 4: Earth and Space	
4.1.1	▲ identifies properties of the solid earth, the oceans and fresh water, and the atmosphere.
4.1.2	▲ models earth's cycles, constructive and destructive processes, and weather systems.
4.2.1	▲ understands that earth processes observed today (including movement of lithospheric plates and changes in atmospheric conditions) are similar to those that occurred in the past; earth history is also influenced by occasional catastrophes, such as the impact of a comet or asteroid.
4.3.1	▲ compares and contrasts the characteristics of stars, planets, moons, comets, and asteroids.
4.3.2	models spatial relationships of the earth/moon/planets/sun system to scale.
4.3.3	identifies past and present methods used to explore space.
4.4.1	▲ demonstrates and models object/space/time relationships that explain phenomena such as the day, the month, the year, seasons, phases of the moon, eclipses and tides.
4.4.2	describes how the angle of incidence of solar energy striking earth's surface affects the amount of heat energy absorbed at earth's surface.

6th Grade Recommendations

Integrated	
2.1.1	▲ compares and classifies the states of matter; solids, liquids, gases, and plasma
2.1.2	compares and contrasts the classes of matter; elements, compounds, and mixtures.
2.1.3	identifies and communicates properties of matter including but not limited to, boiling point, solubility, and density.
2.2.1	▲ understands the relationship of atoms to elements and elements to compounds. (Introduction only.)
2.2.2	▲ measures and graphs the effects of temperature on matter.
3.1.4	concludes that breakdowns in structure or function may be caused by disease, damage, heredity, or aging.
3.3.1	▲ understands that internal and/or environmental conditions affect an organism's behavior and/or response in order to maintain and regulate stable internal conditions to survive in a continually changing environment.
3.3.2	recognizes that the survival of all organisms requires the ingestion of materials, the intake and release of energy, growth, release of wastes and responses to environmental change.
3.5.2	▲ understands that adaptations of organisms (changes in structure, function, or behavior that accumulate over successive generations) contribute to biological diversity.
3.5.3	▲ associates extinction of a species with environmental changes and insufficient adaptive characteristics.
4.1.1	▲ identifies properties of the solid earth, the oceans and fresh water, and the atmosphere.
4.1.2	▲ models earth's cycles, constructive and destructive processes, and weather systems.
4.2.1	▲ understands that earth processes observed today (including movement of lithospheric plates and changes in atmospheric conditions) are similar to those that occurred in the past; earth history is also influenced by occasional catastrophes, such as the impact of a comet or asteroid.

6th Grade (Standard-Specific)

Standard 2: Physical Science	
2.1.1	▲ compares and classifies the states of matter; solids, liquids, gases, and plasma
2.1.2	compares and contrasts the classes of matter; elements, compounds, and mixtures.
2.1.3	identifies and communicates properties of matter including but not limited to, boiling point, solubility, and density.
2.2.1	▲ understands the relationship of atoms to elements and elements to compounds.
2.2.2	▲ measures and graphs the effects of temperature on matter.
2.3.1	identifies the forces that act on an object (e.g., gravity and friction)
2.3.2	▲ describes, measures, and represents data on a graph showing the motion of an object (position, direction of motion, speed).
2.3.3	▲ recognizes and describes examples of Newton's Laws of Motion.
2.3.4	▲investigates and explains how simple machines multiply force at the expense of distance.
2.4.1	understands the difference between potential and kinetic energy.
2.4.2	▲ understands that when work is done energy transforms from one form to another, including mechanical, heat, light, sound, electrical, chemical, and nuclear energy, yet is conserved.
2.4.3	▲ observes and communicates how light (electromagnetic) energy interacts with matter: transmitted, reflected, refracted, and absorbed.
2.4.4	▲ understands that heat energy can be transferred from hot to cold by radiation, convection, and conduction.

7th Grade Recommendations

Integrated	
2.2.1	▲ understands the relationship of atoms to elements and elements to compounds.
2.3.1	identifies the forces that act on an object (e.g., gravity and friction)
2.3.2	▲ describes, measures, and represents data on a graph showing the motion of an object (position, direction of motion, speed).
2.3.3	▲ recognizes and describes examples of Newton's Laws of Motion.
2.4.2	▲ understands that when work is done energy transforms from one form to another, including mechanical, heat, light, sound, electrical, chemical, and nuclear energy, yet is conserved.
2.4.4	▲ understands that heat energy can be transferred from hot to cold by radiation, convection, and conduction.
3.1.1	▲ will understand the cell theory; that all organisms are composed of one or more cells, cells are the basic unit of life, and that cells come from other cells.
3.1.2	▲ relates the structure of cells, organs, tissues, organ systems, and whole organisms to their functions
3.1.3	compares organisms composed of single cells with organisms that are multi-cellular.
3.2.1	▲ differentiates between asexual and sexual reproduction of organisms.
3.2.2	understands how hereditary information of each cell is passed from one generation to the next.
3.2.3	infers that the characteristics of an organism result from heredity and interactions with the environment.
3.4.3	▲ traces the energy flow from the sun (source of radiant energy) to producers (via photosynthesis – chemical energy) to consumers and decomposers in food webs.
3.5.1	concludes that species of animals, plants, and microorganisms may look dissimilar on the outside but have similarities in internal structures, developmental characteristics, chemical processes, and genomes.
4.4.1	▲ demonstrates and models object/space/time relationships that explain phenomena such as the day, the month, the year, seasons, phases of the moon, eclipses and tides.
4.4.2	describes how the angle of incidence of solar energy striking earth's surface affects the amount of heat energy absorbed at earth's surface.

7th Grade (Standard-Specific)

Standard 3: Life Science	
3.1.1	▲ will understand the cell theory; that all organisms are composed of one or more cells, cells are the basic unit of life, and that cells come from other cells.
3.1.2	▲ relates the structure of cells, organs, tissues, organ systems, and whole organisms to their functions
3.1.3	compares organisms composed of single cells with organisms that are multi-cellular.
3.1.4	concludes that breakdowns in structure or function may be caused by disease, damage, heredity, or aging.
3.2.1	▲ differentiates between asexual and sexual reproduction of organisms.
3.2.2	understands how hereditary information of each cell is passed from one generation to the next
3.2.3	infers that the characteristics of an organism result from heredity and interactions with the environment
3.3.1	▲ understands that internal and/or environmental conditions affect an organism's behavior and/or response in order to maintain and regulate stable internal conditions to survive in a continually changing environment.
3.3.2	recognizes that the survival of all organisms requires the ingestion of materials, the intake and release of energy, growth, release of wastes and responses to environmental change.
3.4.1	▲ recognizes that all populations living together (biotic resources) and the physical factors (abiotic resources) with which they interact compose an ecosystem.
3.4.2	understands how limiting factors determine the carrying capacity of an ecosystem.
3.4.3	▲ traces the energy flow from the sun (source of radiant energy) to producers (via photosynthesis – chemical energy) to consumers and decomposers in food webs.
3.5.1	concludes that species of animals, plants, and microorganisms may look dissimilar on the outside but have similarities in internal structures, developmental characteristics, chemical processes, and genomes.
3.5.2	▲ understands that adaptations of organisms (changes in structure, function, or behavior that accumulate over successive generations) contribute to biological diversity.
3.5.3	▲ associates extinction of a species with environmental changes and insufficient adaptive characteristics.

Appendix III

The Kansas high school science assessment consists of two halves (Life Science and Physical Science). Both halves of the science assessment include Earth/Space Science (ESS) indicators. Since an ESS course is not available at all high schools and/or may not be a required course in all schools, an alternative for ESS standard incorporation is provided below. This alternative is an alignment of ESS standards, benchmarks, and indicators in courses beyond ESS and has been designed to ensure ESS concepts can be covered through eighth grade integrated science, biology, and physical science (physics and/or chemistry) courses. This alternative is strictly a recommendation. There are two formats of this alternative below; one with a vocabulary list and one without.

ESS Standards recommended to be taught in 8th grade/ Life Science/ Physical Science	
8th Grade	**Life Science**
4.1.1 (Mastered) Understands constructive and destructive processes, including weathering, erosion and deposition, dynamically reshape the surface of the earth. a. The rock cycle describes constructive and destructive processes that change the forms of rocks and soil (solid earth). b. Water, glaciers, winds, waves, and gravity are weathering and erosion agents.	x
4.1.2 a, c (Mastered) ▲ Understands the theory of Plate Tectonics explains that internal energy drives the earth's ever changing structure. a. Movable continental and oceanic plates make up earth's surface; the hot, convecting mantle is the energy source for plate movement. c. Convection circulation in the mantle is driven by the outward transfer of earth's internal heat.	x
4.1.3 The ultimate source of atmospheric and oceanic energy comes from the sun. Energy flow drives global climate and weather. Climate and weather are influenced by geographic features, cloud cover, and earth's rotation. a. Energy from the sun heats the oceans and the atmosphere, and drives oceanic and atmospheric circulation. d. Weather patterns and seasonal weather change are multi-variable phenomena. f. Weather in the troposphere redistributes water on the surface of the earth through the water cycle. i. Concepts and skills include basic weather forecasting, weather maps, fronts, pressure systems, severe storms and safety precautions.	4.1.3 The ultimate source of atmospheric and oceanic energy comes from the sun. Energy flow drives global climate and weather. Climate and weather are influenced by geographic features, cloud cover, and earth's rotation. b. Human activity impacts global climate. Example: Burning of fossil fuels produces ground level ozone that hinders plant growth. c. The composition and structure of earth's atmosphere is a factor in the earth's suitability to support life. e. Biogeochemical cycles are an example of the integration of earth, physical, and biological science concepts. g. The ozone layer in the upper stratosphere filters UV radiation which is harmful to living things. h. Gamma radiation and other high energy radiation from the sun is filtered by the upper atmosphere.

8th Grade	Life Science
4.2.1 b, e ▲ Understands geological time is used to understand the earth's past. b. Earth changes can be short term (during a human's lifetime), such as earthquakes and volcanic eruptions, or long term (over a geological time scale), such as mountain building and plate movements. e. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent.	4.2.1 a, c, d, e ▲ Understands geological time is used to understand the earth's past. a. Radioactive dating and relative dating (i.e. stratigraphy, fossils) are used to estimate the time rocks were formed. c. The earth's atmosphere has changed over time. For example: The dramatic changes in earth's atmosphere (i.e. introduction of O2) which were affected by the emergence of life on earth. d. Relates geologic evidence to a record of earth's historye. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent. e. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent.

Physical Science
4.1.2 b, d, e (Mastered) ▲ Understands the theory of Plate Tectonics explains that internal energy drives the earth's ever changing structure. b. Essentially all energy on earth originates with the sun, is generated by radioactive decay in earth's interior, or is left over from earth's formation. d. Systems on earth's surface are powered principally by the sun and contain an essentially fixed amount of each stable chemical atom or element. e. Rocks, water, CO2/ O2, carbon and other nutrients cycle through different forms as a result of cycle biological and geologic processes.
4.3.1 Understands gravitational attraction of objects in the solar system keeps solar system objects in orbit. a. Kepler's laws describe planetary motion. b. Newton's laws of inertia and gravity explain orbital motion. c. Because of the sun's large mass, the sun is the primary gravitational force in the solar system.
4.3.2 ▲ Understands the relationship between the earth, moon, and sun explains the seasons, tides and moon phases. a. The angle of incidence of solar energy striking earth's surface effect the amount of heat energy absorbed at earth's surface. b. The gravitational relationship between the earth, moon, and sun causes tides.
4.3.3 Understands the relative sizes and distances of objects in the solar system.

4.3.4 Understands the sun, earth, and other objects in the solar system formed from a nebular cloud of dust and gas.

4.4.1 ▲ Understands stellar evolution.

a. Condensation of gases, due to gravity, is a foundation for the formation of stars

b. The life cycle of the star begins with the nebula, which contains mostly hydrogen and helium. Heavier elements were, and continue to be, made by the nuclear fusion reactions in stars.

c. The Hertzsprung-Russell (H-R) diagram is used to classify stars. The sun is a main sequence star.

d. Stars are classified by their color, temperature, age, apparent brightness and distance from earth.

4.4.2 Understands the current scientific explanation of the origin and structure of the universe.

a. The formation of the universe began with an expansion of gases from a hot, dense state. By studying the light emitted from distant galaxies, it has been found that galaxies are moving apart from one another.

b. The red shift of light, within the Doppler effect, emitted by distance galaxies supports the conclusion that the universe is expanding.

c. Galaxies are a level of organization of the universe. There are at least 100 billion galaxies in the observable universe. Galaxies are organized into superclusters with large voids between them.

d. The sun is a second-generation star, which, along with our galaxy (The Milky Way which includes about 100 billion stars) formed billions of years after the Big Bang.

4.4.3 Understand how the tools of astronomy have revolutionized the study of the universe.

a. Current telescopes can measure across the Electromagnetic-Spectrum.

b. Spectral analysis is used to determine chemical composition and energy of stars.

c. Relative mass of objects can be determined by observing motion of objects in space and the effect one object's gravity has on another.

d. The tools and skills of astronomers have changed through time: ancient astronomy (Stonehenge, Greeks, Chinese, Aristotle) through modern astronomy (Copernicus to present).

e. Astronomical tools and skills allow astronomers to research phenomena and objects that cannot be observed and measured directly.

ESS Standards recommended to be taught in 8th grade/ Life Science/ Physical Science	
8th Grade	**Vocabulary**
4.1.1 (Mastered) Understands constructive and destructive processes, including weathering, erosion and deposition, dynamically reshape the surface of the earth. a. The rock cycle describes constructive and destructive processes that change the forms of rocks and soil (solid earth). b. Water, glaciers, winds, waves, and gravity are weathering and erosion agents.	o Constructive process o Destructive process o Weathering o Erosion o Deposition o Rock cycle
4.1.2 a, c (Mastered) ▲ Understands the theory of Plate Tectonics explains that internal energy drives the earth's ever changing structure. a. Movable continental and oceanic plates make up earth's surface; the hot, convecting mantle is the energy source for plate movement. c. Convection circulation in the mantle is driven by the outward transfer of earth's internal heat.	o Plate tectonics o Convection circulation o Mantle o Convection currents o Continental drift o Seismic activity o Convergent plate boundary o Divergent plate boundary o Transform or slip
4.1.3 ▲ The ultimate source of atmospheric and oceanic energy comes from the sun. Energy flow drives global climate and weather. Climate and weather are influenced by geographic features, cloud cover, and earth's rotation. a. Energy from the sun heats the oceans and the atmosphere, and drives oceanic and atmospheric circulation. d. Weather patterns and seasonal weather change are multi-variable phenomena. f. Weather in the troposphere redistributes water on the surface of the earth through the water cycle. i. Concepts and skills include basic weather forecasting, weather maps, fronts, pressure systems, severe storms and safety precautions.	o Weather patterns o Seasons o Atmospheric layers o Fronts o Pressure systems
4.1.4 (Mastered) * Understands the processes of water cycling through surface water (oceans, lakes, streams, glaciers), ground water (aquifers), and the atmosphere. (hydrological cycle). a. Processes of evaporation, condensation, precipitation, transpiration, runoff, and filtration move water through the water cycle. b. Weather in the troposphere redistributes water on the surface of the earth through the water cycle. c. Ground water is stored in aquifers and moved through underground streams. d. Water in the atmosphere is in the form of water vapor and clouds.	o Water (hydrologic) cycle o Groundwater (aquifers) o Surface water o Atmosphere o Evaporation o Condensation o Precipitation o Transpiration o Runoff o Filtration

4.2.1 b, e ▲ Understands geological time is used to understand the earth's past. b. Earth changes can be short term (during a human's lifetime), such as earthquakes and volcanic eruptions, or long term (over a geological time scale), such as mountain building and plate movements. e. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent.	o Geological time scale
Life Science	**Vocabulary**
4.1.3 The ultimate source of atmospheric and oceanic energy comes from the sun. Energy flow drives global climate and weather. Climate and weather are influenced by geographic features, cloud cover, and earth's rotation. b. Human activity impacts global climate. Example: Burning of fossil fuels produces ground level ozone that hinders plant growth. c. The composition and structure of earth's atmosphere is a factor in the earth's suitability to support life. e. Biogeochemical cycles are an example of the integration of earth, physical, and biological science concepts. g. The ozone layer in the upper stratosphere filters UV radiation which is harmful to living things. h. Gamma radiation and other high energy radiation from the sun are filtered by the upper atmosphere.	o Global climate o Biogeochemical cycles o Ozone layer
4.2.1 a, c, d, e ▲ Understands geological time is used to understand the earth's past. a. Radioactive dating and relative dating (i.e. stratigraphy, fossils) are used to estimate the time rocks were formed. c. The earth's atmosphere has changed over time. For example: The dramatic changes in earth's atmosphere (i.e. introduction of O2) which were affected by the emergence of life on earth. d. Relates geologic evidence to a record of earth's historye. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent. e. Matching coastlines, similarities in rock types, similarities in fossils and life forms suggest that today's continents are separated parts of what was long ago a single continent.	o Geologic time o Radioactive dating o Relative dating o Radioactive decay o Geological time scale o Mass Extinction o Glaciation o Climatic changes o Principle of superposition

Physical Science	Vocabulary
4.1.2 b, d, e (Mastered) ▲ Understands the theory of Plate Tectonics explains that internal energy drives the earth's ever changing structure. b. Essentially all energy on earth originates with the sun, is generated by radioactive decay in earth's interior, or is left over from earth's formation. d. Systems on earth's surface are powered principally by the sun and contain an essentially fixed amount of each stable chemical atom or element. e. Rocks, water, CO_2/O_2, carbon and other nutrients cycle through different forms as a result of cycle biological and geologic processes.	o Rock cycle o Water cycle o CO_2/O_2 cycle o Carbon cycle o Nutrient cycle o Radioactive decay
4.3.1 Understands gravitational attraction of objects in the solar system keeps solar system objects in orbit. a. Kepler's laws describe planetary motion. b. Newton's laws of inertia and gravity explain orbital motion. c. Because of the sun's large mass, the sun is the primary gravitational force in the solar system.	o Gravitational force o Kepler's Laws of Planetary Motion o Orbital motion
4.3.2 ▲ Understands the relationship between the earth, moon, and sun explains the seasons, tides and moon phases. a. The angle of incidence of solar energy striking earth's surface effect the amount of heat energy absorbed at earth's surface. b. The gravitational relationship between the earth, moon, and sun causes tides.	o Seasons o Tides o Moon phases (new, crescent, waxing, waning, new, old, first, third, quarter, gibbous, full) o Lunar eclipse o Solar eclipse o Earth o Moon o Sun o Angle of incidence
4.3.3 Understands the relative sizes and distances of objects in the solar system.	
4.3.4 Understands the sun, earth, and other objects in the solar system formed from a nebular cloud of dust and gas.	
4.4.1 ▲ Understands stellar evolution. a. Condensation of gases, due to gravity, is a foundation for the formation of stars b. The life cycle of the star begins with the nebula, which contains mostly hydrogen and helium. Heavier elements were, and continue to be, made by the nuclear fusion reactions in stars. c. The Hertzsprung-Russell (H-R) diagram is used to classify stars. The sun is a main sequence star. d. Stars are classified by their color, temperature, age, apparent brightness and distance from earth.	o Stellar evolution o Nebula o Hertzsprung-Russell (H-R) diagram o Brightness – apparent o Nuclear fusion o Main sequence o Giants o Dwarfs

4.4.2 Understands the current scientific explanation of the origin and structure of the universe. a. The formation of the universe began with an expansion of gases from a hot, dense state. By studying the light emitted from distant galaxies, it has been found that galaxies are moving apart from one another. b. The red shift of light, within the Doppler effect, emitted by distance galaxies supports the conclusion that the universe is expanding. c. Galaxies are a level of organization of the universe. There are at least 100 billion galaxies in the observable universe. Galaxies are organized into superclusters with large voids between them. d. The sun is a second-generation star, which, along with our galaxy (The Milky Way which includes about 100 billion stars) formed billions of years after the Big Bang.	o Doppler Effect o Red shift o Clusters o Superclusters o Levels of organization (sun, solar system, galaxy, cluster, supercluster, universe) o Big Bang theory
4.4.3 Understand how the tools of astronomy have revolutionized the study of the universe. a. Current telescopes can measure across the Electromagnetic-Spectrum. b. Spectral analysis is used to determine chemical composition and energy of stars. c. Relative mass of objects can be determined by observing motion of objects in space and the effect one object's gravity has on another. d. The tools and skills of astronomers have changed through time: ancient astronomy (Stonehenge, Greeks, Chinese, Aristotle) through modern astronomy (Copernicus to present). e. Astronomical tools and skills allow astronomers to research phenomena and objects that cannot be observed and measured directly.	o Telescope o Spectral analysis o Galaxies o Electromagnetic-Spectrum o Space shuttle o Space probe o Space station