INSPIRED STANDARDS MATCH FOR KANSAS

Science Education Standards

Meeting curriculum standards is a major focus in education today. This document highlights the correlation of Inspiration® with the Kansas Science Education Standards.

The Inspired Standards Match is designed to demonstrate the many ways Inspiration supports the standards and to give educators ideas for using this tool to meet learning goals across the curriculum.

How to read the Inspired Standards Match:

• Pink highlight indicates a standard or objective that is supported by the use of Inspiration
• Green note annotation includes names of an Inspiration template that corresponds to the highlighted standard. These templates are part of the software program and act as starters or frameworks for student work.

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KANSAS

Science Education Standards

Kansas State Board of Education
Adopted February14, 2001

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Dedication

The writing committee dedicates the *Kansas Science Education Standards* to all Kansas students. Our students are the future of Kansas. With this document, we pass on the legacy of our own teachers, who helped us to know that as lifelong learners of science, we can live more productive, responsible, and fulfilling lives.

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Kansas Science Education Standards

Introduction

Mission Statement
The mission of science education in Kansas is to utilize science as a vehicle to prepare **all** students as lifelong learners who can use science to make reasoned decisions, contributing to their local, state, and international communities.

Vision Statement

> "All students, regardless of gender, cultural or ethnic background, future aspirations or interest and motivation in science, should have the opportunity to attain high levels of scientific literacy" (Annenberg/CPB Math and Science Project, 1996, T-7).

The educational system must prepare the citizens of Kansas to meet the challenges of the 21st century. With this in mind, the intent for the *Kansas Science Education Standards* can be expressed in a single phrase: Science standards for all students. The phrase embodies both excellence and equity. These standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science.

By emphasizing both excellence and equity, these standards also highlight the need to give students the opportunity to experience science to learn science. Students can achieve high levels of performance with:
- access to skilled professional teachers;
- adequate classroom time;
- a rich array of learning material;
- accommodating work spaces; and
- the resources of the communities surrounding their schools.

Responsibility for providing this support falls on all those involved with the system of education in Kansas.

Inquiry is central to science learning. These standards call for more than "science as a process," in which students learn discrete skills such as observing, inferring, and experimenting. When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills. They also experience first-hand the thrill and excitement of science. As a result of such experiences, students will be empowered to add to the growing body of scientific knowledge.

The importance of inquiry does not imply that all teachers should pursue a single approach to teaching science. Just as inquiry has many different facets, so do teachers need to use many different strategies to develop the understandings and abilities described here. These standards rest on the premise that science is an active process. Science is something that students and adults do, not something that is done to them.

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.

These standards should not be viewed as a state curriculum nor as requiring a specific local curriculum. A curriculum is the way content is organized and presented in the classroom. The content embodied in these standards can be organized and presented with many different emphases and perspectives in many different curricula.

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. Also, they will 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.

Students may need further support in and beyond the regular classroom to attain these expectations. Teachers, school administrators, parents, and other community members should be provided with the professional development and leadership resources necessary to enable them to help all students work toward meeting or exceeding these expectations.

Background Information

The original *Kansas Curricular Standards for Science* were 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 science committee was charged to:

1. Bring greater clarity and specificity to what teachers should teach and students should learn at the various grade levels.
2. Review current state curricular standards.
3. Prioritize the standards to be assessed by the state assessments.
4. Provide advice regarding assessment methodologies.

Acknowledgment of Prior Work

Carrying out this charge, the writing committee built upon and benefited from a great deal of prior work done on a national level. Two principal expressions of a unified vision and content for science education exist. One is the *National Science Education Standards* published by the National Research Council; the second is *Benchmarks for Science Literacy* from Project 2061 of the American Association for the Advancement of Science. According to representatives of both groups, the vision and content overlap by at least 80%. These standards embrace the vision and content of the *National Science Education Standards* (National Research Council, 1996) and *Benchmarks for Science Literacy* (Project 2061 AAAS, 1993). Therefore, the *Kansas Science Education Standards* are founded not only on the research base but also 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. Thus, the *Kansas Science Education Standards* are consistent with both expressions of a unified vision for science education. Moreover, the National Science Teachers Association recently published elementary, middle, and high school editions of *Pathways to the Science Standards.* The pathways documents provide a framework for aligning the *Kansas Science Education Standards* with national standards. All of the above mentioned documents contain many resources and teaching applications for further development of the ideas presented in the *Kansas Science Education Standards*. Permission to use specific segments of text in the *Kansas Science Education Standards* has been requested from the National Research Council, the American Association for the Advancement of Science, the National Science Teachers Association. Permission to use a diagram has been requested from the Lawrence Hall of Science at the University of California – Berkeley.

Nature of Science

Science is the human activity of seeking natural explanations for what we observe in the world around us. Science does so through the use of observation, experimentation, and logical argument while maintaining strict empirical standards and healthy skepticism. Scientific explanations are built on observations, hypotheses, and theories. A hypothesis is a testable statement about the natural world that can be used to build more complex inferences and explanations. A theory is a well-substantiated explanation of some aspect of the natural world that can incorporate observations, inferences, and tested hypotheses.

Scientific explanations must meet certain criteria. Scientific explanations are consistent with experimental and/or observational data and testable by scientists through additional experimentation and/or observation. Scientific explanation must meet criteria that govern the repeatability of observations and experiments. The effect of these criteria is to insure that scientific explanations about the world are open to criticism and that they will be modified or abandoned in favor of new explanations if empirical evidence so warrants. Because all scientific explanations depend on observational and experimental confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core theories of science have been subjected to a wide variety of confirmations and have a high degree of reliability within the limits to which they have been tested. In areas where data or understanding are incomplete, new data may lead to changes in current theories or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest. Science has flourished in different regions during different time periods, and in history, diverse cultures have contributed scientific knowledge and technological inventions. Changes in scientific knowledge usually occur as gradual modifications, but the scientific enterprise also experiences periods of rapid advancement. The daily work of science and technology results in incremental advances in our understanding of the world about us.

Teaching With Tolerance and Respect

A teacher is an important role model for demonstrating respect, sensitivity, and civility. Teachers should not ridicule, belittle or embarrass a student for expressing an alternative view or belief. In doing this, teachers display and demand tolerance and respect for the diverse ideas, skills, and experiences of all students. If a student should raise a question in a natural science class that the teacher determines to be outside the domain of science, the teacher should treat the question with respect. The teacher should explain why the question is outside the domain of natural science and encourage the student to discuss the question further with his or her family and other appropriate sources.

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 dogmatically.

A Perspective on Changing Emphases

The central nature of inquiry in learning science reflects substantive changes - steps forward - from the previous *Kansas Curricular Standards for Science*, last updated in 1995. The *Kansas Science Education Standards* envision change throughout the system of Kansas education. These standards reflect the following changes in emphases, as shown in the chart below:

Changing Emphases in the Nature of Science Content
and
Changing Emphases to Promote Inquiry

Less Emphasis On	More Emphasis On
• Knowing only scientific facts and information.	• Understanding scientific concepts and developing abilities of inquiry.
• Covering many science topics.	• Studying a few fundamental science concepts.
• Implementing inquiry as a set of isolated processes.	• Implementing inquiry as instructional strategies, abilities, learning ideas, and integrated processes.
• Activities that demonstrate a known science concept.	• Activities that generate, investigate, and analyze science questions.
• Investigations confined to one class period.	• Investigations over extended periods of time.
• Individual process skills such as observation or inference taken out of context.	• Using multiple process skills such as manipulation, cognitive, and procedural skills in the context of inquiry.
• Getting an answer.	• Using evidence and strategies for developing or revising an explanation.
• Individuals and groups of students analyzing and synthesizing data without defending a conclusion.	• Groups of students often analyzing and synthesizing data and defending conclusions.
• Teachers providing answers to questions about science content.	• Students building and communicating scientific explanations.

To help readers grasp the extent of changing emphases presented in the chart immediately above, the writing committee has included two sections from the prior Kansas standards in the appendices. Readers can find the classical science process skills defined in Appendix 4 and the Diagram Explanation for the Science Standards in Appendix 2. Regarding science process skills, these standards call for substantive change- for a decrease in emphasis on implementing inquiry as a set of isolated process skills, with a simultaneous increase on implementing inquiry as instructional strategies, ideas, and abilities to be learned. Close examination of the chart above reveals that science processes remain important, as they should. But, in these standards, students acquire proficiency in science processes within the context of learning to do scientific inquiry. This requires students to develop their abilities to think scientifically. To encourage a uniform understanding of what this means, the writing committee has also included a diagram on the Scientific Thinking Processes in Appendix 3.

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, 8, 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, 5-8, and 9-12.

1. Science as Inquiry
2. 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

These 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, 8, and 12.

Indicators

These 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 should the list be considered as all-inclusive. Moreover, the list of examples under each indicator should be considered as representative but not as comprehensive or all-inclusive.

Examples

Two kinds of examples are presented. An instructional example offers an activity or a specific concrete instance of an idea of what is called for by an indicator. A clarifying example provides an illustration of the meaning or intent of an indicator. Like the indicators themselves, examples are considered to be representative but not comprehensive or all-inclusive.

Keying the Standards to the Kansas Science Assessment

Readers should notice that selected indicators beneath standards have a box containing a number immediately to the left of the number of the indicator. The presence of such an internally numbered box beside an indicator means that the writing committee has designated this indicator for emphasis on the new Kansas Science Assessments, which have been developed to assess these standards. Thus, a box with the number "4" inside represents an indicator to be emphasized on the Grade 4 Kansas Science Assessment. Similarly, boxes with the numbers "7" or "10" inside represent indicators to be emphasized on the Grade 7 and Grade 10 Kansas Science Assessments, respectively. **Those indicators preceded by a box with a grade number and three asterisks (e.g. 4*** or 7*** or 10***) have been chosen for assessment on the Kansas State Science Assessments beginning in 2001. The other marked indicators (those without asterisks) should be considered for local assessment.**

Unifying Concepts and Processes in the *Kansas Science Education Standards*

Science is traditionally a discipline-centered activity; however, broad, unifying concepts and processes exist which cut across the traditional disciplines of science. Five such concepts and processes, which are named and described below, have been embedded within and across the seven standards. These broad unifying concepts and processes complement the analytic, more discipline-based perspectives presented in the other content standards. Moreover, they provide students with productive and insightful ways of thinking about integrating a range of basic ideas that explain the world about us, including what occurs naturally as well as what is built by humans through science and technology. The embedded unifying concepts and processes named and described below are a subset of the many unifying ideas in science and technology. These were selected from the *National Science Education Standards* because they provide connections between and among traditional scientific disciplines, are fundamental and comprehensive, are understandable and usable by people who will implement science programs, and can be expressed and experienced in a developmentally appropriate manner during K-12 science education.

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 for the convenience of investigations. 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, transportation and education. 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. 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 on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in naturally occurring systems and systems built by humans. 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. Terms, such as “law” and “principle” describe regularities or consistent patterns of nature. Terms such as “hypothesis,” “model,” “theory,” and “paradigm” describe various types of scientific explanations.

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, motion, and form and function of systems. Interactions within and among systems result in change. 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 knowing when to use which system. 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 biological theory of evolution, which explains the process of descent with modification of organisms from common ancestors. Additional examples are continental drift, which is part of plate tectonic theory, fossilization, 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.

On the following page, a K-12 overview of science content is presented within the seven standards. At the beginning of the 4th (p. 19), 8th (p. 32), and 12th (p. 62) grade standards, the overview of science content for that section within the seven standards is connected to the unifying concepts and processes.

Overview of 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
By the End of 12th Grade	• Abilities necessary to do scientific inquiry	Chemistry • Structure of atoms • Structure & properties of matter • Chemical reactions Physics • Motions & forces • Conservation of energy & increase in disorder • Interactions of energy & matter	• The cell • Molecular basis of heredity • Biological evolution • Interdependence of organisms • Matter, energy, & organization in living systems • Behavior of organisms • Structure, function, & diversity of organisms	• Energy in the Earth system • Interactions of Earth's subsystems • Origin & evolution of the Earth system • Origin & evolution of the universe	• Abilities of technological design and understanding about science & technology	• Personal health • Population growth • Natural resources and environmental quality • Natural & human-induced hazards • Science, technology, and society	• Science as a human endeavor • Nature of scientific understanding • Historical perspectives
By the End of 8th Grade	• Abilities necessary to do scientific inquiry • Designing investigations • Understanding about scientific inquiry	• Properties of matter • Changes in properties of matter • Motions & forces • Transfer of energy	• Structure & function in living systems • Reproduction & heredity • Regulation & behavior • Populations & ecosystems • Diversity & adaptations of organisms	• Structure of the Earth system • Past & present Earth processes • Components of the solar system • Motion & forces which affect Earth phenomena	• Abilities of technological design • Understanding about science & technology	• Personal Health • Populations, resources, & environments • Risks & causes of natural hazards	• Scientific habits of mind • Contributions to science throughout history
By the End of 4th Grade	• Abilities necessary to do scientific inquiry, understanding about & participating in scientific inquiry	• Properties of objects & materials • Position & motion of objects • Electricity, & magnetism • Sound	• Organisms and their environments • Life cycles of organisms	• Properties of earth materials • Objects in the sky • Changes in earth & sky	• Problem solving skills • Apply understanding of science & technology • Abilities to distinguish between natural objects & objects made by humans	• Personal health • Changes in surroundings	• People practice science

By The End Of EIGHTH GRADE

Overview of Science Standards 5-8

	Unifying concepts and processes *				
	Systems, Order & Organization	**Evidence, Models & Explanations**	**Change, Constancy, & Measurement**	**Patterns of Cumulative Change**	**Form & Function**
SCIENCE AS INQUIRY					
• Abilities necessary to do scientific inquiry		**X**	**X**		
• Designing investigations		**X**	**X**		
• Understanding about scientific inquiry		**X**	**X**		
PHYSICAL SCIENCE					
• Properties of matter			**X**		**X**
• Changes in properties of matter			**X**		**X**
• Motions and forces			**X**		
• Transfer of energy	**X**	**X**	**X**		
LIFE SCIENCE					
• Structure and function in living systems	**X**				**X**
• Reproduction and heredity	**X**	**X**	**X**	**X**	**X**
• Regulation and behavior	**X**		**X**	**X**	**X**
• Populations and ecosystems	**X**	**X**	**X**	**X**	**X**
• Diversity and adaptations of organisms	**X**	**X**	**X**	**X**	**X**
EARTH AND SPACE SCIENCE					
• Structure of the earth system	**X**	**X**	**X**	**X**	**X**
• Past and present earth processes		**X**	**X**	**X**	**X**
• Components of the solar system	**X**	**X**	**X**	***X***	**X**
• Motion and forces which affect earth phenomena	**X**	**X**	**X**		**X**
SCIENCE AND TECHNOLOGY					
• Abilities of technological design		**X**	***X***		**X**
• Understanding about science and technology	**X**	**X**			
SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES					
• Personal health	**X**	**X**	**X**		**X**
• Populations, resources, & environments	**X**	**X**	**X**	**X**	
• Risks and causes of natural hazards		**X**	**X**		
HISTORY & NATURE OF SCIENCE					
• Scientific habits of mind		**X**			
• Contributions to science throughout history		**X**			

*** See pages 8-9**

STANDARD 1: SCIENCE AS INQUIRY

As a result of activities in grades 5-8, all students 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 students will demonstrate abilities necessary to do the processes of scientific inquiry.

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 the 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.

Indicators: The students will:

7*** **1.** Identify questions that can be answered through scientific investigations.

Example: Explore properties and phenomena of materials, such as a balloon, string, straw, and tape. Students explore properties and phenomena and generate questions to investigate.

7*** **2.** Design and conduct a scientific investigation.

Example: Students design and conduct an investigation on the question, “Which paper towel absorbs the most water?” Materials include different kinds of paper towels, water, and a measuring cup. Components of the investigation should include background and hypothesis, identification of independent variable, dependent variable, constants, list of materials, procedures, collection and analysis of data, and conclusions.

7*** **3.** Use appropriate tools, mathematics, technology, and techniques to gather, analyze and interpret data.

Example: Given an investigative question, students determine what to measure and how to measure. Students should display their results in a graph or other appropriate graphic format.

7*** **4.** Think critically to identify the relationship between evidence and logical conclusions.

Example: Students check data to determine: Was the question answered? Was the hypothesis supported/not supported? Did this design work? How could this experiment be improved? What other questions could be investigated?

7 **5.** Apply mathematical reasoning to scientific inquiry.

Examples: Look for patterns from the mean of multiple trials, such as the rate of dissolving relative to different temperatures. Use observations for inductive and deductive reasoning, such as explaining a person's energy level after a change in eating habits (e.g., use Likert-type scale). State relationships in data, such as variables, which vary directly or inversely.

7 **6.** Communicate scientific procedures and explanations.

Example: Present a report of your investigation so that others understand it and can replicate the design.

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

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.

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.

Indicators: The students will:

7 **1.** Differentiate between a qualitative and a quantitative investigation.

Example: While observing a decomposing compost pile, how could you collect quantitative (numerical, measurable) data? How could you collect qualitative (descriptive) data? What is a quantitative question? (e.g., is the temperature constant throughout the compost pile?) What is a qualitative question? (e.g., does the color of the compost pile change over time?)

Examples: Each student designs a question to investigate. Class analyzes all questions to classify as qualitative or quantitative.
After reading a science news article, identify variables and write a qualitative and/or quantitative investigative question related to the topic of the article.

10 **2.** Develop questions and adapt the inquiry process to guide an investigation.

Example: Adapt an existing lab or activity to: write a different question, identify another variable, and/or adapt the procedure to guide a new investigation.

Benchmark 3: The students will analyze how science advances through new ideas, scientific investigations, skepticism, and examining evidence of varied explanations.
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.

Indicators: The students will:

7 **1.** After doing an investigation, generate alternative methods of investigation and/or further questions for inquiry.

Example: Ask "What would happen if…?" questions to generate new ideas for investigation.

10 **2.** Determine evidence which supports or contradicts a scientific breakthrough.

Example: Examine and analyze a scientific breakthrough [such as a Hubble discovery] using multiple, scientific sources. Explain how a reasonable conclusion is supported.

10 **3.** Identify faulty reasoning or conclusions that go beyond evidence and/or are not supported by data.

Example: Analyze evidence and data which support the theory of continental drift.

STANDARD 2: PHYSICAL SCIENCE

As a result of activities in grades 5-8, all students 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 students will observe, compare, and classify properties of matter.
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?"

Indicators: The students will:

7*** **1.** Identify and communicate properties of matter, including phases of matter, boiling point, solubility, and density.

Examples: Measure and graph the boiling point temperatures for several different liquids. Graph the cooling curve of a freezing ice cream mixture. Observe substances that dissolve (sugar) and substances that do not dissolve (sand).

7 **2.** Using the characteristic properties of each original substance, distinguish components of various types of mixtures.

Examples: Separate alcohol and water using distillation. Separate sand, iron filings, and salt using a magnet and water. Observe properties of kitchen powders (baking soda, salt, sugar, flour). Mix in various combinations, then identify by properties.

10 **3.** Categorize chemicals to develop an understanding of properties.

Examples: Create operational definitions of metals and nonmetals and classify by observable chemical and physical properties.

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

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.

Indicators: The students will:

7*** **1.** Measure and graph the effects of temperature on matter.

Examples: Change water from solid to liquid to gas using heat. Measure and graph temperature changes. Observe changes in volume occupied.

10 **2.** Understand that total mass is conserved in chemical reactions.

Example: Measure the mass of an Alka Seltzer tablet, water, and a container with a lid. Then drop in tablet, close tightly, and measure the mass after the reaction.

10 **3.** Understand the relationship of elements to compounds.

Example: Draw a diagram to show how different compounds are composed of elements in various combinations.

Benchmark 3: The students will investigate motion and forces.
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.

Indicators: The students will:

7*** **1.** Describe motion of an object (position, direction of motion, speed, potential, and kinetic energy).

Examples: Follow the path of a toy car down a ramp. The ramp is first covered with tile and then with sandpaper. Trace 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.

7*** **2.** Measure motion and represent data in a graph.

Example: Roll a marble down a ramp. Make adjustments to the board or to the marble's position in order to hit a target located on the floor. Measure and graph the results.

10 **3.** Demonstrate an understanding that an object not being subjected to a force will continue to move at a constant speed in a straight line (Law of Inertia).

Example: Place a small object on a rolling toy vehicle; stop the vehicle abruptly; observe the motion of the small object. Relate to personal experience - stopping rapidly in a car.

10 **4.** Demonstrate and mathematically communicate that unbalanced forces will cause changes in the speed or direction of an object's motion.

Example: With a ping pong ball and 2 straws, investigate the effects of the force of air through two straws on the ping-pong ball with the straws at the same side of ball, on opposite sides, and at other angles. Illustrate results with vectors (force arrows).

7 **5.** Understand that a force (e.g., gravity and friction) is a push or a pull.

Example: Explore 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.

7 **6.** Investigate force variables of simple machines.

Example: Investigate the load (force) that can be moved as the number of pulleys in a system is increased.

Benchmark 4: The students will understand and demonstrate the transfer of energy.
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 sources of energy for life systems, while heat convection currents deep within the earth are energy source 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.

Indicators: The students will:

7 **1.** Understand that energy can be transferred from one form to another, including mechanical, heat, light, electrical, chemical, and nuclear energy.

Examples: Design an energy transfer device. Use various forms of energy. The device should accomplish a simple task such as popping a balloon. Explore sound waves using a spring.

7 **2.** Sequence the transmission of energy through various real life systems.

Example: Draw a chart of energy flow through a telephone from the caller's voice to the listener's ear.

7*** **3.** Observe and communicate how light interacts with matter: transmitted, reflected, refracted, absorbed.

Example: Classify classroom objects as to how they interact with light: a window transmits; black paper absorbs; a projector lens refracts; a mirror reflects.

7*** **4.** Understand that heat energy can be transferred from hot to cold by radiation, convection, and conduction.

Example: Add colored warm water to cool water. Observe convection. Measure and graph temperature over time.

STANDARD 3: LIFE SCIENCE

As a result of activities in grades 5-8, all students 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 students will model structures of organisms and relate functions to the structures.

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.

Indicators: The students will:

7*** **1.** Relate the structure of cells, organs, tissues, organ systems, and whole organisms to their functions.

Examples: Identify human body organs and characteristics. Then relate their characteristics to function. Map human body systems, research their functions and show how each supports the health of the human body. Relate an organism's structure to how it works.

7*** **2.** Compare organisms composed of single cells with organisms that are multi-cellular.

Example: Create and compare 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.

10 **3.** Conclude that breakdowns in structure or function of an organism may be caused by disease, damage, heredity or aging.

Example: Compare lung capacity of smokers with that of non-smokers and graph the results.

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

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.

Indicators: The students will:

7 **1.** Conclude that reproduction is essential to the continuation of a species.

Examples: Observe and communicate the life cycle of an organism (seed to seed; larva to larva; or adult to adult). Culture more than one generation (life cycle) of an invertebrate organism. Discuss implications of one generation of the species not reproducing.

7*** **2.** Differentiate between asexual and sexual reproduction in plants and animals.

Examples: Compare the regeneration of a planarian to the reproduction of an earthworm.
Compare 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 to an ovum.

7*** **3.** Infer that the characteristics of an organism result from heredity and interactions with the environment.

Example: Choose an organism. Research its characteristics. Infer if these characteristics result from heredity, environment, or both.

10 **4.** Understand that hereditary information contained in the genes (part of the chromosomes) of each cell is passed from one generation to the next.

Examples: In a cooperative setting, have students trace parent characteristics with those of an offspring.
Use coin tossing to predict the probability of traits being passed on. Remember that not all traits are single gene traits.

Benchmark 3: The students will describe the effects of a changing external environment on the regulation/balance of internal conditions and processes of organisms.

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.

Indicators: The students will:

7*** **1.** Understand the effects of a change in environmental conditions on behavior of an organism by carrying out a full investigation.

Examples: Select a variable to alter the environment (e.g., temperature, light, moisture, gravity) and observe the effects on an organism (e.g., pillbug or earthworm). Students could also think of their own behaviors and determine environmental conditions that affect behavior.

7*** **2.** Identify behaviors of an organism that are responses made to internal or environmental stimuli.

Example: Observe 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.

10 **3.** Explain that all organisms must be able to maintain and regulate stable internal conditions to survive in a constantly changing external environment.

Example: Investigate the effects of various stimuli on plants and how they adapt their growth: phototropism, geotropism, and thermotropism are examples.

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

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 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.

Indicators: The students will:

7 **1.** Recognize that all populations living together and the physical factors with which they interact compose an ecosystem.

Examples: Create a classroom terrarium and identify the interactions between the populations and physical conditions needed for survival. Participate in a field study examining the living and non-living parts of a community.

7*** **2.** Classify organisms in a system by the function they serve (producers, consumers, decomposers).

Example: Explore populations at a pond, field, forest floor, and/or rotting log. Have students identify the various food webs and observe that organisms in a system are classified by their function.

7*** **3.** Trace the energy flow from the sun (source) to producers (chemical energy) to other organisms in food webs.

Example: Role-play the interactions and energy flow of organisms in a food web. Pass 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.

7 **4.** Relate the limiting factors of biotic and abiotic resources with a species' population growth, decline, and survival

Examples: Change variables such as a 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? Participate in a simulation such as "Oh Deer" from Project Wild.

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

Millions of species of animals, plants and microorganisms are alive today. Animals and plants vary in body plans and internal structures. Biological evolution, gradual changes of characteristics of organisms over many generations, has brought 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 helps develop understanding of natural selection over time. (Resource: *The Beak of the Finch* by Jonathon Weiner). 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.

Indicators: The students will:

7 **1.** Conclude that millions of species of animals, plants, and microorganisms may look dissimilar on the outside but have similarities in internal structures, developmental characteristics, and chemical processes.

Examples: Research numerous organisms and create a classification system based on observations of similarities and differences. Compare this system with a dichotomous key used by scientists. Explore various ways animals take in oxygen and give off carbon dioxide.

7*** **2.** Understand that adaptations of organisms - changes in structure, function, or behavior - contribute to biological diversity.

Example: Compare characteristics of birds such as beaks, wings, and feet, with how a bird behaves in its environment. Then students work in cooperative groups to design different parts of an imaginary bird. Relate characteristics and behaviors of that bird with its structures.

7*** **3.** Associate extinction of a species with environmental changes and insufficient adaptive characteristics.

Example: Students use various objects to model bird beaks, such as spoons, toothpicks, clothespins. Students use "beaks" to "eat" several types of food, such as cereal, raisins, noodles. When "food" sources change, those species that have not adapted die.

STANDARD 4: EARTH and SPACE SCIENCE

As a result of activities in grades 5-8, all students 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 students will understand that the structure of the earth system is constantly changing due to the earth's physical and chemical processes.

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, the water cycle, and the carbon 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.

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.

Indicators: The students will:

7*** **1.** Predict patterns from data collected.

Example: Map the movement of weather systems and predict the local weather conditions.

7*** **2.** Identify properties of the solid earth, the oceans and fresh water, and the atmosphere.

Examples: Create a concept map of earth materials using links to show connections, such as water causing erosion of solid, wind evaporating water, etc. Compare the densities of salt and fresh water. Classify rocks, minerals, and soil by properties. Compare heating and cooling over land and water.

7*** **3.** Model earth's cycles.

Examples: Create rock cycle and water cycle dioramas.
Illustrate global ocean and wind currents. Flow-chart a carbon atom through the carbon cycle.

10 **4.** Model earth's plate movements that result in major geologic events and landform development.

Example: Plot the location of the earth's plate boundaries and compare with recent volcano and earthquake activity in the Ring of Fire. Refer to US Geologic Survey data available on the Internet.

10 **5.** Understand water's major role in changing the solid surface of the earth, such as the effect of oceans on climates and water as an erosion force.

Examples: Map major climate zones and relate to ocean currents. Model top soil erosion. Measure sediment load in a nearby stream.

Benchmark 2: The students will understand that past and present earth processes are similar.
The constructive and destructive forces we see today are similar to those that occurred in the past. Constructive forces include crustal formation by plate movement, volcanic eruptions, earthquakes, and deposition of sediments. Destructive forces include weathering, erosion, and glacial action. 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 the 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.

Indicators: The students will:

7*** **1.** Understand the dynamics of earth's constructive and destructive forces over time.

Examples: Construct 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.
Use an acid (vinegar or dilute HCl) to show the chemical similarity of limestone rock and fossilized shells.
Students take a piece of sandstone and apply destructive forces to change it into sand. Observe the effects of weathering on various rock types.

10 **2.** Model geologic time to scale.

Example: "Toilet Paper Earth History:": Plot the major events (last ice age, beginning of Paleozoic Era, etc.) of earth history on a roll of toilet paper. Each sheet of toilet paper = 100 million years.

10 **3.** Relate geologic evidence to a record of earth's history.

Examples: Locate the same rock layer in two local road cuts; give fossil evidence and other kinds of evidence that the layer is the same in both exposures. Compare the types of organisms shown in the fossils found in a Kansas shale (mudstone) and a Kansas limestone and infer the ocean depositional environment from which the rock layer was formed.

10 **4.** Compare the current arrangement of the continents with the arrangement of continents throughout the earth's history.

Examples: Cut out continents from a world map and slide them together to see how they fit. Plot each continental plate's latitude and longitude through earth's history.

Benchmark 3: The students will identify and classify planets and other solar system components.
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. The 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.

Indicators: The students will:

7 **1.** Compare and contrast the characteristics of the planets.

Example: Search reliable Internet sources for current information. Create a graphic organizer to visualize comparisons of planets.

7*** **2.** Develop understanding of spatial relationships via models of the earth/moon/planets/sun system to scale.

Examples: Model the solar system to scale in a long hallway or school yard using rocks for rocky planets and balloons for gaseous planets. Designate a large object as the sun. Model the earth/moon/sun system to scale with the question: If the 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. Research smaller components of the solar system such as asteroids and comets.

Example: Identify and classify characteristics of asteroids and comets.

10 **4.** Identify the sun as a star and compare its characteristics to those of other stars.

Examples: Classify bright stars visible from earth by color, temperature, age apparent brightness, and distance from earth.
Sequence the life cycle of a star.

5. Trace cultural as well as scientific influences on the study of astronomy.

Example: Research ancient observations and explanations of the heavens and compare with today's knowledge.

Benchmark 4: The students will model motions and identify forces that explain earth phenomena.
There are many motions and forces that affect the 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 the 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. Teachers can help students make connections between force and motion concepts, such as Newton's Laws of Motion and Newton's Law of Universal Gravitation, and applications to earth and space science. 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?

Indicators: The students will:

7*** **1.** Demonstrate object/space/time relationships that explain phenomena such as the day, the month, the year, and the seasons.

Example: Use an earth/moon/sun model to demonstrate a day, a month, a year, and the seasons.

10 **2.** Model earth/moon positions that create phases of the moon and eclipses.

Example: Use students to demonstrate the relative positions of the sun, earth and moon to create eclipses, phases of the moon, and tides using a circle of students representing the fluid water.

10 **3.** Apply principles of force and motion to understand the solar system.

Examples: Use string and ball model to illustrate gravity and movement creating an orbit around a hand.

10 **4.** Understand the effect of the angle of incidence of solar energy striking the earth's surface on the amount of heat energy absorbed at the earth's surface.

Examples: Place a piece of graph paper on the surface of a globe at the equator. Hold a flashlight 10 cm. from the paper parallel to the globe. Mark the lighted area of the paper. Then, place the graph paper at a high latitude. Again hold the flashlight parallel to the paper 10 cm from the paper. Compare the areas lit at the equator and at the high latitude, with the same amount of light energy. Where does each lighted square of paper receive the most energy?

STANDARD 5: SCIENCE AND TECHNOLOGY

As a result of activities in grades 5-8, all students will demonstrate abilities of technological design and understandings about science and technology.

Benchmark 1: The students will demonstrate abilities of technological design.
Technological design focuses on creating new products for meeting human needs. 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?

Indicators: The students will:

7 **1.** Identify appropriate problems for technological design.

Examples: Design a measurement instrument (e.g., weather instruments) for a science question that students are investigating.
Select and research a current technology, then project how it might change in the next twenty years.

7*** **2.** Design a solution or product, implement the proposed design, evaluate the product.

Example: Design, create and evaluate a product that meets a need or solves a problem in a student's life.

3. Communicate the process of technological design.

Example: Keep a log of designing (and building) a technology, then use the log to explain the process.

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

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.

Indicators: The students will:

7 **1.** Compare the work of scientists with that of applied scientists and technologists.

Example: A scientist studies air pressure. A technologist designs an airplane wing. Complete a Venn diagram to compare the processes of scientists and technologists.

2. Evaluate limitations and trade-offs of technological solutions.

Example: Select a technology to evaluate using a graphic organizer. List uses, limitations, possible consequences.

3. Identify contributions to science and technology by many people and many cultures.

Example: Using a map of the world, mark the locations for people and events that have contributed to science.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

As a result of activities in grades 5-8, all students 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 students will make decisions based on scientific understanding of personal health.

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.

Parents and teachers need to work in partnership to help students understand that they, the middle level students, not some outside force (parents, school, the law), are the ultimate decision-makers about their own personal health. The challenge to teachers is to help students apply scientific understanding to health decisions by giving the students opportunities to gather evidence and draw their own conclusions on topics such as smoking, healthy eating, wearing bike helmets, and wearing car seat belts.

Indicators: The students will:

7*** **1.** Identify individual nutrition, exercise, and rest needs based on science.

Example: Design, implement, and self-evaluate a personal nutrition and exercise program.

7 **2.** Use a systemic approach to thinking critically about personal health risks and benefits.

Examples: Compare and contrast immediate benefits of eating junk food to long term benefits of a lifetime of healthy eating.
Evaluate the risks and benefits of foods, medicines, and personal products. Evaluate and compare the nutritional and toxic properties of various natural and synthetic foods.

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

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.

Indicators: The students will:

7 **1.** Investigate the effects of human activities on the environment.

Examples: Count the number of cars that pass the school during a period of time. Investigate the effects of traffic volume on environmental quality (e.g., water and air quality, plant health).
Investigate the effects of repeatedly walking off the sidewalks. Discuss the implications for the environment. Participate in an environmental Internet study.

2. Base decisions on perceptions of benefits and risks.

Example: Evaluate the benefits of burning fossil fuels to meet energy needs against the risks of global warming.

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

Indicators: The students will:

7 **1.** Evaluate risks and define appropriate actions associated with natural hazards.

Example: Find news articles that show inadvisable risks taken in a natural hazard situation.

10 **2.** Recognize patterns of internal and external earth processes that may result in natural hazards.

Example: Build wood block models of plate boundary interaction: subduction, translation, and spreading.

10 **3.** Communicate human activities that can cause/contribute to natural hazards.

Example: How can channeling a stream promote flooding downstream? Borrow a County Conservation Commission's stream trailer to investigate the dynamics of a stream and the effects of human interaction with the stream.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

As a result of activities in grades 5-8, all students will examine and develop an understanding of science as a historical human endeavor.

Benchmark 1: The students will develop scientific habits of mind.
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 mediums, and they can self-evaluate their learning. High expectations for accuracy, reliability, and openness to differing opinions should be exercised. The indicators listed below can be embedded within the other standards.

Indicators: The students will:

1. Practice intellectual honesty.

Examples: Analyze news articles to evaluate if the articles apply statistics/data to bring clarity, or if the articles use data to mislead.
Analyze data and recognize that an hypothesis not supported by data should not be perceived as a right or wrong answer.

2. Demonstrate skepticism appropriately.

Example: Students will attempt to replicate an investigation to support or refute a conclusion.

3. Display open-mindedness to new ideas.

Example: Share interpretations that differ from currently held explanations on topics such as global warming and dietary claims. Evaluate the validity of results and accuracy of stated conclusions.

4. Base decisions on evidence.

Example: Review 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.

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

Indicators: The students will:

1. Recognize that new knowledge leads to new questions and new discoveries.

Examples: Discuss discoveries that replaced previously held knowledge, such as safety of freon or saccharine use, knowledge concerning the transmission of AIDS, cloning, Pluto's status as a planet.

2. Replicate historic experiments to understand principles of science.

Example: Rediscover principles of electromagnetism by replicating Oersted's compass needle experiment. (Compass needle deflects perpendicular to current carrying wire.)

3. Relates contributions of men and women to the fields of science.

Example: Research the contributions of men and women of science, create a timeline to demonstrate the ongoing contributions of dedicated scientists from across ethnic, religious, and gender lines.

By The End Of **TWELFTH GRADE**

Overview of Science Standards 9-12

Unifying concepts and processes *

	Systems, Order & Organization	Evidence, Models & Explanations	Change, Constancy, & Measurement	Patterns of Cumulative Change	Form & Function
SCIENCE AS INQUIRY					
• Abilities necessary to do scientific inquiry	X	X	X	X	X
CHEMISTRY					
• Structure of atoms	X	X	X	X	
• Structure and properties of matter	X	X	X		X
• Chemical reactions	X		X	X	X
PHYSICS					
• Motions and forces	X	X	X		X
• Conservation of energy & increase of disorder	X	X	X	X	X
• Interactions of energy and matter	X	X	X		
LIFE SCIENCE					
• The cell	X	X	X	X	X
• Molecular basis of heredity	X	X	X	X	X
• Biological evolution	X	X	X	X	X
• Interdependence of organisms	X	X	X	X	
• Matter, energy & organization in living systems	X	X	X	X	X
• Behavior of organisms		X	X	X	X
• Structure, function, and diversity of organisms	X			X	X
EARTH AND SPACE SCIENCE					
• Energy in the earth system	X	X	X	X	X
• Interactions of earth's subsystems	X	X	X	X	X
• Origin and evolution of the earth system	X	X	X	X	X
• Origin and evolution of the universe	X	X	X	X	
SCIENCE AND TECHNOLOGY					
• Abilities of technological design and understanding about science & technology	X	X	X		X
SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES					
• Personal health	X		X		X
• Population growth	X	X	X	X	
• Natural resources and environmental quality	X		X		X
• Natural and human-induced hazards	X	X	X		
• Science, technology and society	X	X	X		X
HISTORY & NATURE OF SCIENCE					
• Science as a human endeavor	X	X			
• Nature of scientific knowledge	X	X	X	X	X
• Historical perspectives	X	X	X	X	X

*** See pages 8-9**

STANDARD 1: SCIENCE AS INQUIRY

As a result of their activities in grades 9-12, all students will develop the abilities necessary to do scientific inquiry and understandings about scientific inquiry.

Benchmark 1: Students will demonstrate the fundamental abilities necessary to do scientific inquiry.

Indicators: The students will:

1. Develop a rich understanding and curiosity of the natural (material) world through experience.

Example: Students must have a rich set of experiences to draw on in order to ask and evaluate research questions.

10* 2.** Develop questions and identify concepts that guide scientific investigations.

Examples: Formulate a testable hypothesis, where appropriate, and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. Demonstrate a knowledge base, appropriate procedures, and conceptual understanding of scientific investigations.

10* 3.** Design and conduct scientific investigations.

Examples: Requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. May also require student clarification of the question, method (including replication), controls, variables, display of data, revision of methods and replication of explanations, followed by a public presentation of the results with a critical response from peers. Always, students must use evidence, apply logic, and construct an argument for their proposed explanations.

10*** **4.** Use technology and mathematics to improve investigations and communications.

Examples: A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, organization, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations, and communicating results.
Technology is used to gather and manipulate data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.

5. Formulate and revise scientific explanations and models using logic and evidence.

Example: Student inquiries should culminate in formulating an explanation or model. Models can be physical, conceptual, or mathematical. In the process of answering the questions, the students should engage in discussions that result in the revision of their explanations. Discussions should be based on scientific knowledge, the use of logic, and evidence from their investigations.

6. Recognize and analyze alternative explanations and models.

Example: Emphasize the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, students should be able to use scientific criteria to determine the supported explanation(s).

7. Communicate and defend a scientific argument.

Example: These abilities include writing procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments.

STANDARD 2A: CHEMISTRY

As a result of their activities in grades 9-12, all students will develop an understanding of the structure of atoms, chemical reactions, and the interactions of energy and matter.

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

Indicators: The students will understand:

10 **1.** Atoms are the fundamental organizational unit of matter.

10 **2.** Atoms have smaller components that have measurable mass and charge.

10* ** **3.** The nucleus of an atom is composed of protons and neutrons, which determine the mass of the atom.

10* ** **4.** The dense nucleus of an atom is in the center of an electron cloud, and the electron cloud determines the size of the atom.

10 **5.** Isotopes are atoms with the same number of protons but different numbers of neutrons.

6. Radioactive isotopes spontaneously decompose and are a source of radioactivity.

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

Indicators: The students will understand:

10 **1.** Elements are substances that contain only one kind of atom.

10* ** **2.** Elements are arranged according to increasing atomic number on the periodic table.

10 **3.** The periodic table organizes elements according to similar physical and chemical properties by groups, periods, and categories.

Examples: Elements in the same group share similar chemistry. Periods indicate an energy level of the outermost electrons. Categories are regions such as metals, non-metals, and transition elements.

4. There are discrete energy levels for electrons in an atom.

Example: 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 which form visible light. Indeed, when there is color, there are electrons changing energy levels.

5. Valence electrons (those farthest from the nucleus or highest energy electrons) determine the chemistry of the atom.

10* 6.** Chemical bonds result when electrons are transferred or shared between atoms.

7. Compounds result from chemical bonds between ions or atoms.

Examples: Ionic compounds result from an attraction between ions of opposite charge (ionic bond). Molecular compounds result from atoms sharing electrons (covalent bond).

8. The nature of interactions among ions or between molecular compounds determines their physical properties.

Examples: Molecules may exist as gases, liquids or solids. The hydrogen bond is an intermolecular attraction responsible for the properties of water and many biological molecules. Ionic compounds are generally solids.

9. Kinetic models are used to explain the physical properties of gases.

10. 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.

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

Indicators: The students will:

1. Understand that two or more of the following may often identify chemical reactions: physical property change, effervescence, mass change, precipitation, light emission, and heat exchange.

2. Explore chemical reactions that absorb energy from or release energy to the surroundings.

3. Distinguish different types of chemical reactions such as synthesis, decomposition, combustion, displacement, acid/base, and oxidation/reduction.

4. Demonstrate the Law of Conservation of Mass through stoichiometric relationships.

5. Appreciate the significance of chemical reactions in nature and those used everyday in society.

6. Recognize entropy (degree of disorder) as a driving force behind chemical reactions.

7. Assess the interrelationships between the rate of chemical reactions and variables such as temperature, concentration, catalysts, and reaction type.

STANDARD 2B: PHYSICS

Benchmark 1: The students will understand the relationship between motions and forces.

Indicators: The students will understand:

10*** **1.** The motion of an object can be described in terms of its displacement (position), velocity, and acceleration.

10*** **2.** Objects change their motion only when a net force is applied.

Examples: When no net force acts, the object either doesn't move or moves with constant speed in a straight line. When a net force acts upon an object, the object will change its motion. The magnitude of the change in motion is given by the relationship $\sum F=ma$, regardless of the type of force.

3. Whenever a system applies force to an object, that object applies a related force to the system that is equal in magnitude and opposite in direction.

Example: The change in an object's motion (acceleration) is in the direction of the net applied force.

4. Gravitation is a relatively weak, attractive force that acts upon and between any two masses.

5. Electric force is the attraction or repulsion that exists between two charged particles. Its magnitude is vastly greater than that due to gravity.

10 **6.** Electricity and magnetism are two aspects of a single electromagnetic force.

Example: Moving electrical charges produce magnetic forces, and moving magnets produce electrical forces.

Benchmark 2: The students will understand the conservation of mass and energy, and that the overall disorder of the universe increases with time.

Indicators: The students will understand:

10* 1.** The energy of the universe is constant.

Examples: Physicists view matter as equivalent to energy.
Matter and energy cannot be created or destroyed, but they can be interchanged.

10 2. Energy may be classified as kinetic, potential, or energy within a field.

Examples: Kinetic energy deals with the motion of objects. Potential energy results from objects' relative configuration. Electromagnetic radiation is an example of energy contained within a field. These energies are interchangeable : kinetic to potential, potential to kinetic, potential to field, etc.

3. Heat is the transfer of energy from objects at higher temperature to objects at lower temperature.

Examples: The internal energy of substances consists in part of movement of atoms, molecules, and ions. Temperature is a measure of the average magnitude of this movement. Heat is an exchange of internal energy between systems.

4. The universe tends to become less organized and more disordered with every chemical and physical change.

Benchmark 3: The students will understand the basic interactions of matter and energy.

Indicators: The students will understand:

1. Waves can transfer energy when they interact with matter.

2. Electromagnetic waves result when a charged object is accelerated.

Example: Electromagnetic waves include radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, and gamma rays.

3. Each kind of atom or molecule can gain or lose energy in unique, discrete amounts.

Examples: Atoms and molecules can absorb and emit light only at wavelengths corresponding to specific amounts of energy. These wavelengths can be used to identify the substance and form the basis for several forms of spectroscopy.

10 **4.** Electrons flow easily in conductors (such as metals). Semiconducting materials have intermediate behavior. At low temperatures, some materials become superconductors and offer little or no resistance to the flow of electrons.

STANDARD 3: LIFE SCIENCE

As a result of their activities in grades 9-12, all students 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: Students will demonstrate an understanding of the structure and function of the cell.

Indicators: Students will understand that:

10*** **1.** Cells are composed of a variety of specialized structures that carry out specific functions.

Example: Every cell is surrounded by a membrane that separates it from the outside environment and controls the flow of materials into and out of the cell. Proteins embedded in the membrane help to carry out specific life processes. In eukaryotes, similar membranes and their associated proteins help to compartmentalize and isolate the various chemical environments of the cell into organelles. Organelles are specialized to carry out specific life functions for the cell such as protein synthesis, protein processing and packaging, energy transformation, communication, etc.

10 **2.** Most cell functions involve specific chemical reactions.

Example: Food molecules taken into cells provide the chemicals needed to synthesize other molecules. Enzymes catalyze both breakdown and synthesis in the cell. In eukaryotes these reactions take place in membrane-bound organelles.

10*** **3.** Cells function and replicate as a result of information stored in DNA and RNA molecules.

Example: Proteins and gene expression regulate cell functions. This regulation allows cells to respond to their environment and to control and coordinate cell division.

10 **4.** Some plant cells contain chloroplasts, which are the sites of photosynthesis.

Example: The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. The cell is the basic unit of function for living things.

5. Cells can differentiate, thereby enabling complex multicellular organisms to form.

Example: In the development of most multicellular organisms, a fertilized cell forms an embryo that differentiates into an adult. Differentiation is regulated through expression of different genes and leads to the formation of specialized cells, tissues, and organs.

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

Indicators: The students will understand:

10*** **1.** Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait.

Examples: Alleles, which are different forms of a gene, may be dominant, recessive, co-dominant, etc.
The expression of traits is determined by a complex interaction of genes, developmental history, and the environment.

10*** **2.** Experiments have shown that all known living organisms contain DNA or RNA as their genetic material.

Examples: Frederick Griffith & Avery's work with bacteria demonstrated that DNA changed properties of cells.
Beadle & Tatum's work provided a mechanism for gene action and a link to modern molecular genetics.
Hershey and Chase's work demonstrated that viral DNA contained the genetic code for new virus production in bacterial cells.

10*** **3.** DNA (or RNA) provides the instructions that specify the characteristics of organisms.

Examples: Nucleotides (adenine, thymine, guanine, cytosine and uracil) make up DNA and RNA molecules.
Sequences of nucleotides that either determine or contribute to a genetic trait are called genes.
DNA is replicated by using a template process that usually results in identical copies.
DNA is packaged in chromosomes during cell replication.

4. Organisms usually have a characteristic numbers of chromosomes; one pair of these may determine the sex of individuals.

Example: Most cells in humans contain 23 pairs of chromosomes; the 23rd pair contains the XX for female or XY for male.

5. Gametes carry the genetic information to the next generation.

Examples: Gametes contain only one representative from each chromosome pair. Gametes unite to form a new individual in most organisms. Many possible combinations of genes explain features of heredity such as how traits can be hidden for several generations.

6. Mutations occur in DNA at very low rates.

Examples: Some changes make no difference to the organism or to future generations. Phenotypic changes can be harmful; some mutations enable organisms to survive changes in their environment.
Only mutations in the germ cells are passed on to offspring and therefore can bring about beneficial or harmful changes in future generations.

Benchmark 3: Students will understand the major concepts of the theory of biological evolution.* **(see p. 76)**

Indicators: The students will understand:

1. That the theory of evolution is both the history of descent, with modification of different lineages of organisms from common ancestors, and the ongoing adaptation of organisms to environmental challenges and changes (modified from Futuyma, et al., 1999).

10*** **2.** That biologists use evolution theory to explain the earth's present day biodiversity—the number, variety and variability of organisms.

Example: Patterns of diversification and extinction of organisms are documented in the fossil record. The fossil record provides evidence of simple, bacteria-like life as far back as *3.8+* billion years ago.
Natural selection, and other processes, can cause populations to change from one generation to the next.
A single population can separate into two or more independent populations. Over time, these populations can also become very different from each other. If the isolation continues, the genetic separation may become irreversible. This process is called speciation.
Populations, and entire lineages, can go extinct. One effect of extinction is to increase the apparent differences between populations. As intermediate populations go extinct, the surviving lineages can become more distinct from one another.

3. That biologists recognize that the primary mechanisms of evolution are natural selection and genetic drift.

Example: Natural selection includes the following concepts: 1) heritable variation exists in every species; 2) some heritable traits are more advantageous to reproduction and/or survival than are others; 3) there is a finite supply of resources required for life; not all progeny survive; 4) individuals with advantageous traits generally survive to reproduce; 5) the advantageous heritable traits increase in the population through time.

10*** **4.** The sources and value of variation.

Examples: Variation of organisms within and among species increases the likelihood that some members will survive under changed environmental conditions.
New heritable traits primarily result from new combinations of genes and secondarily from mutations or changes in the reproductive cells; changes in other cells of a sexual organism are not passed to the next generation.

5. That evolution is a broad, unifying theoretical framework in biology.

Examples: Evolution provides the context in which to ask research questions and yields valuable insights, especially in agriculture and medicine.
The common ancestry of living things allows them to be classified into a hierarchy of groups; these classifications or family trees follow rules of nomenclature; scientific names have unique definitions and value.
Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record that correlates with geochemical (e.g., radioisotope) dating results. The distribution of fossil and modern organisms is related to geological and ecological changes (i.e. plate tectonics, migration).

***Understand:** "Understand" does not mandate "belief." While students may be required to understand some concepts that researchers use to conduct research and solve practical problems, they may accept or reject the scientific concepts presented. This applies particularly where students' and/or parents' beliefs may be at odds with current scientific theories or concepts. See *Teaching About Evolution and the Nature of Science*, National Academy of Sciences, 1998, page 59.

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

Indicators: The students will understand:

10 **1.** Atoms and molecules on the earth cycle among the living and nonliving components of the biosphere.

Example: The chemical elements, essential elements of life, circulate in the biosphere in characteristic paths known as biogeochemical cycles (e.g., nitrogen, carbon, phosphorus, etc).

10* 2.** Energy flows through ecosystems.

Examples: Organisms, ecosystems, and the biosphere possess thermodynamic characteristics that exhibit a high state of internal order. Radiant energy that enters the earth's surface is balanced by the energy that leaves the earth's surface.
Transfer of energy through a series of organisms in an ecosystem is called the food chain; at each transfer as much as 90% of the potential energy is lost as heat.

10* 3.** Organisms cooperate and compete in ecosystems.

Example: The interrelationships and interdependence of organisms may generate stable ecosystems.

10 4. Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions among organisms.

Example: The presence and success of an organism, or a group of organisms, depends upon a large number of environmental factors.

10 5. Human beings live within and impact ecosystems.

Example: Humans modify ecosystems as a result of population growth, technology, and consumption. Human modifications of habitats through direct harvesting, pollution, atmospheric changes, and other factors affect ecosystem stability.

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

Indicators: The students will develop an understanding that:

10 **1.** Living systems require a continuous input of energy to maintain their chemical and physical organization.

Example: All matter tends toward more disorganized states.
With death and the cessation of energy intake, living systems rapidly disintegrate.

10*** **2.** The sun is the primary source of energy for life through the process of photosynthesis.

Example: Plants capture energy by absorbing light and using it to form simple sugars. The energy in these sugar molecules can be used to assemble larger molecules with biological activity, including proteins, DNA, carbohydrates, and fats. These molecules serve as sources of energy for life processes.

10*** **3.** Food molecules contain energy. This energy is made available by cellular respiration.

Examples: Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed.
Cells usually use this energy to regenerate ATP, the molecule involved in cell metabolism.

4. The structure and function of an organism serve to acquire, transform, transport, release, and eliminate the matter and energy used to sustain the organism.

10 **5.** The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy, and the ability of the ecosystem to recycle materials.

6. As matter and energy flow through different levels of organization of living systems--cells, organs, organisms, communities--and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in the storage of some energy and a dissipation of some energy into the environment as heat. Matter is recycled, energy is not.

Benchmark 6: Students will understand the behavior of animals.

Indicators: The students will understand that:

1. Animals have behavioral responses to internal changes and to external stimuli.

Examples: Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes. These responses can be innate and/or learned.
Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change.

2. Most multicellular animals have nervous systems that underlie behavior.

Example: Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them.

3. Like other aspects of an organism's biology, behaviors have evolved through natural selection.

Example: Behaviors are often adaptive when viewed in terms of survival and reproductive success. Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology.

Benchmark 7: Students will demonstrate an understanding of structure, function, and diversity of organisms.

Indicators: The students will understand:

1. The basic biology, diversity, ecology, and medical effects of microbiological agents, including prions, viruses, bacteria, and protists.

Examples: Viruses are particles that cause infections. They are composed of genomes encased in a protein shell. They can only reproduce in a host organism. Because of these properties vaccines are effective for viral infection but antibiotics are not. Bacteria are a very diverse group of organisms that account for much of this planet's biomass and cycling of materials. They are prokaryotes. Medically, several infectious diseases (e.g. strep throat, staph infections, cholera, syphilis, food poisoning, etc.) are caused by bacteria. Protists are unicellular eukaryotes whose ancestors gave rise to other major kingdoms. Some are disease agents (e.g. malaria, amoebic dysentery) and may require an animal vector. Understanding of these basic groups underlies effective sanitation and hygiene.

2. The basic biology, diversity, ecology, and medical effects of fungi.

Example: Fungi are vital decomposers and have special symbiotic relationships with plants. Fungi are also important commercially and as the original source of antibiotics. Fungi can also cause disease (e.g. ringworm, athlete's foot, etc.).

10* 3.** The basic biology, diversity, ecology, and human relationships of plants.

Examples: Plant structures vary, and this variation is important in understanding the function of plants in farming, pharmaceutical products, etc.
Photosynthesis is the basis for nearly all food chains and our food production.
Understanding the biology of plants underlies a scientific understanding of ecology.

10* 4.** The basic biology, diversity, anatomy, ecology and medical effects of major animal groups.

Example: Animals vary; this variation is important in understanding the function of animals in farming, medical research, etc.
Understanding the biology of animals underlies a scientific understanding of ecology.

5. That humans can be thought of as complex, soft machines that require many systems to operate properly.

Examples: Organ systems have specific structures and functions; they interact with each other.
Infections, developmental problems, trauma, and aging result in specific diseases and disorders.

10 6. The structures and processes of development and reproduction.

Examples: Reproduction is essential to all ongoing life and is accomplished with wide variation in life cycles and anatomy.
Understanding of basic mechanisms of reproduction and development, as well as changes of aging, is critical to leading a healthy life, parenting, and making societal decisions.
Environmental factors (e.g. radiation, chemicals) can cause inherited gene mutations that directly alter development or cellular repair mechanisms, leading to the development of various cancers. *C*hanges to non-reproductive cell lines are not passed to the next generation.

STANDARD 4: EARTH AND SPACE SCIENCE

As a result of their activities in grades 9-12, students will develop an understanding of energy in the earth system, geochemical cycles, the formation and organization of the earth system, and the organization and development of the universe.

Benchmark 1: Students will develop an understanding of the sources of energy that power the dynamic earth system.

Indicators: The students will understand that:

10 **1.** Essentially all energy on earth originates with the sun, is generated by radioactive decay in the earth's interior, or is left over from the earth's formation.

10 **2.** Convection circulation in the mantle is driven by the outward transfer of the earth's internal heat.

10*** **3.** Movable continental and oceanic plates make up the earth's surface; the hot, convecting mantle is the energy source for plate movement.

10*** **4.** Energy from the sun heats the oceans and the atmosphere, and affects oceanic and atmospheric circulation.

5. Energy flow determines global climate and, in turn, is influenced by geographic features, cloud cover, and the earth's rotation.

Benchmark 2: Students will develop an understanding of the actions and the interactions of the earth's subsystems: the geosphere, hydrosphere, atmosphere and biosphere.

Indicators: The students will understand:

10 **1.** The systems at the earth's surface are powered principally by the sun and contain an essentially fixed amount of each stable chemical atom or element.

10 **2.** The processes of the carbon, rock, and water cycles.

10 **3.** Water, glaciers, winds, waves, and gravity as weathering and erosion agents.

10 **4.** Earth's motions and seasons.

5. The composition and structure of earth's atmosphere.

10 **6.** Severe storms and safety precautions.

10 **7.** Basic weather forecasting, weather maps, fronts, and pressure systems.

Benchmark 3. Students will develop an understanding of the origin and evolution of the dynamic earth system.

Indicators: The students will understand:

10*** **1.** The geologic time scale and how it relates to the history of the earth.

2. Rock sequences, fossils, and radioactive decay and how they are used to estimate the time rocks were formed.

10*** **3.** Earth changes as short term (during a human's lifetime), such as earthquakes and volcanic eruptions, and as long term (over a geological time scale), such as mountain building and plate movements.

4. The dramatic changes in the earth's atmosphere (i.e. introduction of O_2) which were affected by the emergence of life on earth.

10 **5.** The rock cycle describes the formation of rocks.

Benchmark 4. Students will develop an understanding of the organization of the universe, and its development.

Indicators: The students will understand:

1. Organization of the universe.

Example: The sun is an ordinary star. It appears that many stars have planets orbiting them. Our galaxy (The Milky Way) contains about 100 billion stars. Galaxies are a level of organization of the universe. There are at least 100 billion galaxies in the observable universe. Galaxies are organized into large superclusters with large voids between them.

2. Expansion of the universe from a hot dense early state.

Example: By studying the light emitted from distant galaxies, it has been found that galaxies are moving apart from one another. Cosmological understanding including the Big Bang Theory is based on this expansion.

10* 3.** Organization and development of stars, solar systems, and planets.

Example: Nebula from which stars and planets form, are mostly hydrogen and helium. Heavier elements were, and continue to be, made by the nuclear fusion reactions in stars. The sun is a second generation star, which along with it's planets was formed billions of years after the Big Bang.

4. General methods of the exploration of our solar system and space as well as the importance of such exploration.

STANDARD 5: SCIENCE AND TECHNOLOGY

As a result of activities in grades 9-12, all students will develop understandings about science and technology and abilities of technological design.

Benchmark 1: **Students will develop understandings about science and technology.**

Indicators: The students will understand that:

1. Creativity, imagination, and a broad knowledge base are all required in the work of science and engineering.

2. Science and technology are pursued for different purposes.

Examples: Scientific inquiry is driven by the desire to understand the natural world. Applied science technology is driven by the need to meet human needs and solve human problems.

3. Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.

4. Science advances new technologies. New technologies open new areas for scientific inquiry.

5. Technological knowledge is often not made public because of the financial and military potential of the idea or invention. Scientific knowledge is made public through presentations at professional meetings and publications in scientific journals.

STANDARD 6: SCIENCE IN PERSONAL AND ENVIRONMENTAL PERSPECTIVES

As a result of their activities in grades 9-12, all students 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: Students 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.

Indicators: The students will understand that:

1. Hazards and the potential for accidents exist for all human beings.

2. The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease–producing organism.

Examples: Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and are not communicable.

3. Informed personal choices concerning fitness and health involve an understanding of chemistry and biology.

4. Selection of foods and eating patterns determine nutritional balance.

5. Sexuality is basic to healthy human development.

6. Intelligent use of chemical products relates directly to an understanding of chemistry.

Benchmark 2: Students will demonstrate an understanding of population growth.

Indicators: The students will understand that:

10 **1.** Rate of change in populations is determined by the combined effects of birth and death, and emigration and immigration.

Examples: Populations can increase through exponential growth. Population growth changes resource use and environmental conditions.

2. A variety of factors influence birth rates and fertility rates.

10 **3.** Populations can reach limits to growth.

Examples: 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.

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

Indicators: The students will understand that:

1. Natural resources from the lithosphere and ecosystems have been and will continue to be used to sustain human populations.

Examples: 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 to ecosystem function.

2. The earth does not have infinite resources.

Example: Increasing human consumption places stress on most renewable resources and depletes non-renewable resources.

3. Materials from human activities affect both physical and chemical cycles of the earth.

Example: Natural systems can reuse waste, but this capacity is limited.

4. Humans use many natural systems as resources.

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

Indicators: Students will understand that:

1. Natural processes of earth may be hazardous for humans.

Examples: Humans live at the interface between two dynamically changing systems, the atmosphere and the earth's crust. The vulnerability of societies to disruption by natural processes has increased. Natural hazards include volcanic eruptions, earthquakes, and severe weather. Examples of slow, progressive changes are stream channel position, sedimentation, continual erosion, wasting of soil, and landscapes.

2. There is a need to assess potential risk and danger from natural and human induced hazards.

Examples: Human-initiated changes in the environment bring benefits as well as risks to society.
Various changes have costs and benefits. Environmental ethics have a role in the decision-making process.

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

Indicators: The students will understand that:

1. Science and technology are essential components of modern society. Science and technology indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

2. Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various challenges related to science and technology.

3. Progress in science and technology can be affected by social issues and challenges.

STANDARD 7: HISTORY AND NATURE OF SCIENCE

As a result of activities in grades 9-12, all students will develop understanding of science as a human endeavor, the nature of scientific knowledge, and historical perspectives.

Benchmark 1: Students will develop an understanding that science is a human endeavor.

Indicators: The students will:

1. Demonstrate an understanding of science as both vocation and avocation.

2. Explain how science uses peer review, replication of methods, and norms of honesty.

3. Recognize the universality of basic science concepts and the influence of personal and cultural beliefs that embed science in society.

4. Recognize 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. Recognize society's role in supporting topics of research and determining institutions where research is conducted.

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

Indicators: The students will:

10 **1.** Demonstrate an understanding of the nature of scientific knowledge.

Examples: Scientific knowledge is generally empirically based, logical, skeptical, and consistent with observable reality.
Scientific knowledge is subject to experimental or observational confirmation.
Scientific knowledge is built on past understanding and can be refined and augmented.

Benchmark 3: Students will understand science from historical perspectives.

Indicators: The students will:

10 **1.** Demonstrate an understanding of the history of science.

Examples: Modern science has been a successful enterprise that contributes to dramatic improvements in the human condition.
Science progresses by incremental advances of scientists or teams of scientists.
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, medical and health technology.

Appendices

Appendix 1 - Glossary

Appendix 2 - Diagram Explanation of the Science Standards

Appendix 3 - Scientific Thinking Processes

Appendix 4 - Process Skills

Appendix *5* - Bibliography

Appendix 1
Glossary

Terms Concerning the Concepts of Standards

Benchmark: A focused statement of what students should know and be able to do in a subject at specified grade levels.

Curriculum: A particular way that content is organized and presented in the classroom. The content embodied in the *Kansas Science Education Standards* can be organized and presented in many ways through different curricula. Thus, the *Kansas Science Education Standards* do not constitute a state curriculum. However, a specific science curriculum chosen by a school district will be consistent with these standards only if it is consistent with the premises upon which these standards are based (e.g., science for all, equity, developmental appropriateness).

Equity: Within the context of these standards, equity means that these standards apply to all students, regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science.

Example (Clarifying): An illustration of the meaning or intent of an indicator. (Twelfth grade.)

Example (Instructional): An activity or specific concrete instance of an idea of what is called for by an indicator. (Second, fourth, and eighth grades.)

Indicator: A specific statement of what students should know or be able to do as a result of a daily lesson or unit of study and how they will demonstrate what they have learned.

Standard: A description of what students are expected to know and be able to do in a particular subject.

Terms Concerning the Science Content of the *Kansas Science Education Standards*

Believe: To have a firm conviction in the reality of something.

Empirical Science: Science based on experiment and/or observation.

Entropy: A measure of the extent of disorder in a system.

Evolution - Biological: A scientific theory that accounts for present day similarity and diversity among living organisms and changes in non-living entities over time. With respect to living organisms, evolution has two major perspectives: The long-term perspective focuses on the branching of lineages; the short-term perspective centers on changes within lineages. In the long term, evolution is the descent with modification of different lineages from common ancestors. In the short term, evolution is the on-going adaptation of organisms to environmental challenges and changes.

Evolution - Cosmological: With respect to non-living entities, evolution accounts for sequences of natural stages of development. Such sequences are a natural consequence of the characteristics of matter and energy. Stars, planets, solar systems, and galaxies are examples.

Evolution - Macroevolution: Evolution above the species level; the evolution of higher taxa and the product of evolutionary novelties such as new structures (May 1991). Macroevolution continues the genetic mechanisms of microevolution and adds new considerations of extinction, rate and manner of evolution, competition between evolving units, and other topics relevant to understanding larger-scale evolution.

Evolution - Microevolution: The processes (mostly genetic) that operate at the population level: Natural selection, genetic drift, gene flow, and others. These processes may produce genetic differences in populations. These genetic differences, along with reproductive isolation, can lead to speciation, the development of new species.

Gamete: A germ cell (egg or sperm) carrying half of the organism's full set of chromosomes, especially a mature germ cell capable of participating in fertilization.

Genetic Drift: Changes in the gene content of a population owing to chance.

Genotype: The genetic constitution of an individual, especially as distinguished from its physical appearance.

Hypothesis: A testable statement about the natural world that can be used to build more complex inferences and explanations.

Incremental: Within the context of these standards, incremental means that scientists slowly and consistently add to the knowledge base of science by means of scientific work.

Inquiry: Scientific inquiry refers to 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 of 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 many process skills. Conducting hands-on science activities does not guarantee inquiry, nor is reading about science incompatible with inquiry.

Inquiry in School Science (K-4): Full inquiry involves asking a simple question, completing an investigation, answering the question, and presenting the results to others. However, not every activity will involve all of these stages nor must any particular sequence of these stages be followed.

Inquiry in School Science (5-8): Full inquiry involves several parts: Identification of questions that can be answered through scientific investigations; The design and conduct of a scientific investigation; Use of appropriate tools and techniques to gather, analyze, and interpret data; Development of descriptions, explanations, predictions and models using evidence; Thinking critically and logically to make relationships between evidence and explanations. Partial inquiries focus the development of abilities and understanding of selected parts of full inquiry.

Inquiry in School Science (9-12): Full inquiry includes several components: Identification of questions and concepts that guide scientific investigations; The design and conduct of scientific investigations; Use of technology and mathematics to improve investigations and communication; Formulation and revision of scientific explanations and models using logic and evidence; Recognition and analysis of alternative explanations and models. Partial inquiries focus the development of abilities and understanding of selected parts of full inquiry.

Law: A descriptive generalization about how some aspect of the natural world behaves under stated circumstances. Laws are frequently, but not always, mathematical formulations.

Material: The elements, constituents, or substances of which something is composed or can be made.

Operational Definition: The assignment of meaning to a concept or variable in which the activities or operations required to measure it are specified. Operational definitions also may specify the scientist's activities in measuring or manipulating a variable.

Paradigm: A universally recognized theoretical framework in science that, for a time, provides a model for asking questions and seeking answers through science.

Phenotype: The appearance of an individual, including the biochemical traits expressed internally. The genotype may contain genes that are not expressed in the phenotype.

Principle: Similar to a scientific law. A principle frequently, but not always, is a qualitative or descriptive generalization about how some aspect of the natural world behaves under stated circumstances.

Properties: Descriptions of objects based directly on the senses (e.g., hard, soft, smooth) or through extended use of the senses (an atom contains a nucleus).

Qualitative: The concept that entities differ between each other in type or kind.

Quantitative: The concept that entities differ between each other in amount.

Science: The human activity of seeking natural explanations for what we observe in the world around us. These explanations are based on observations, experiments, and logical arguments that adhere to strict empirical standards and a healthy skeptical perspective.

Science Literacy: The scientific knowledge and inquiry skills which enhance a person's ability to observe objects and events perceptively, reflect on them thoughtfully, and comprehend explanations offered for them.

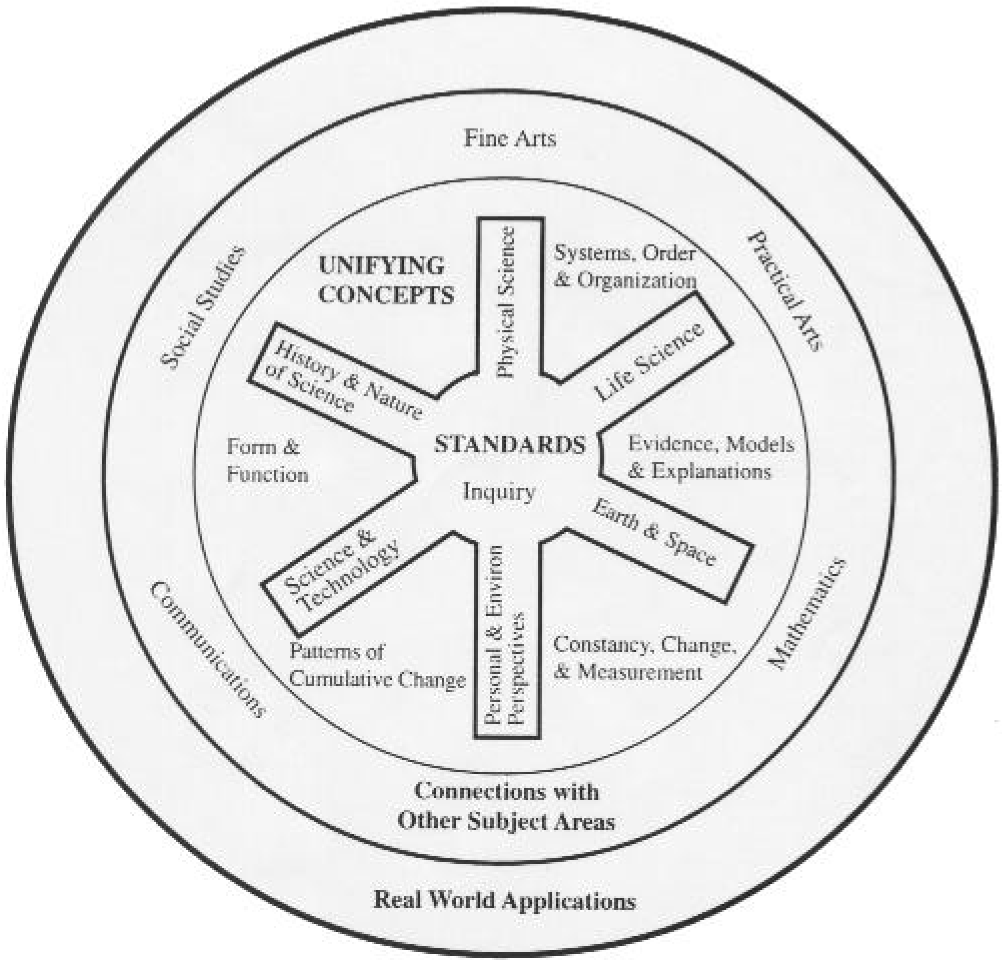
Technology: A science-based activity in which humans start with initial conditions, then design, build, and implement an intervention that improves the world about them in terms of their original needs (e.g., eye glasses or contacts).

Theory: In science, a well-substantiated explanation of some aspect of the natural world that can incorporate laws, inferences, and tested hypotheses (e.g., atomic theory, evolutionary theory).

Understand: To possess a meaningful comprehension of a concept or process based on direct or related experiences. Understanding stands in contrast to memorization, where there is only awareness of a term but no grasp of meaning.

Appendix 2
Diagram Explanation for the Science Standards

Appendix 2
Diagram Explanation for the Science Standards



This diagram illustrates the connections between science Standards, how they relate to the Unifying Concepts, how they are connected with other subject areas, and how they are related to the real world. When teachers use the whole picture as they teach, they provide students with more opportunity to learn, understand, and see the relevance of science, thus promoting not only an informed electorate but also students who are motivated to be lifelong learners.

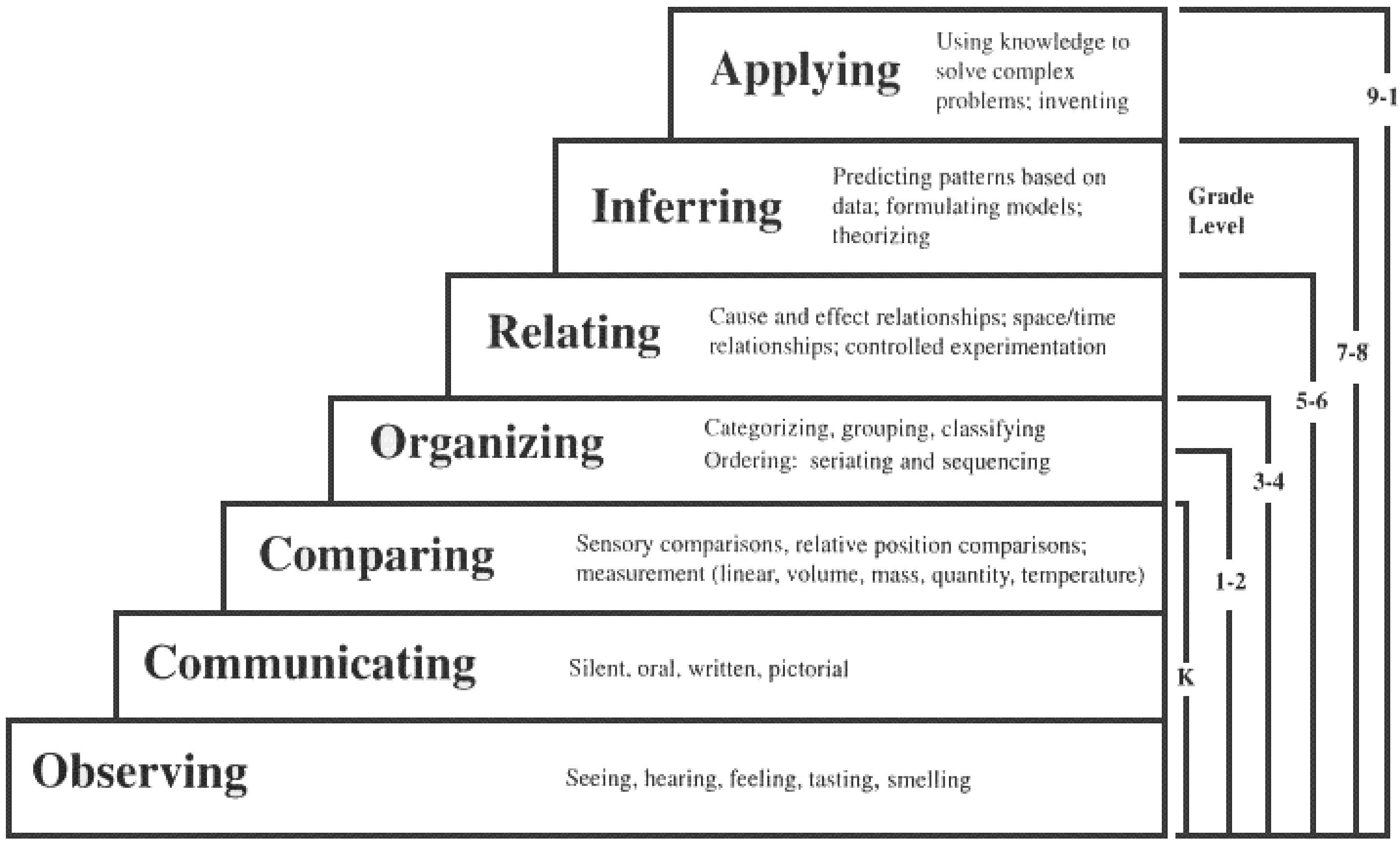
Standards
Content Standards in the life, physical, and earth/space sciences are often closely related, as are the other Standards, and the connections need to be made by teachers to provide a better understanding of science. Inquiry as a Standard is in the center of the diagram and shows that it is an integral part of all the others. Science is much more than a body of information, it is a process of discovery. Through the discovery process, students can learn the content of the Standards and understand it.

Unifying Concepts
To help show the relationships between the Standards, teachers use Unifying Concepts to provide an umbrella for the integration of science topics. These serve to unite the Standards and allow students to grasp the concepts that exist across all of the Content Standards. Using Unifying Concepts, students see the linkages across the science areas and recognize the big picture of science, rather that just one small isolated part.

Connections With Other Subject Areas
Science plays a significant role in other curricular areas as well. For example, students should be able to apply the same knowledge involved in solving an algebraic problem to balancing chemical equations. Students in a science lab could determine how a musical instrument creates its particular sounds. By applying their knowledge of physics, within the Unifying Concepts, students can solve such musical problems. While the same concepts apply to more than one subject area, education has not traditionally linked the various curricular areas.

Real World Applications
The most effective way to teach students about science is to make it relevant to them by showing that what they learn in the classroom has direct application to the world. For example, students at one Kansas school learned some of their most meaningful science lessons when they teamed with a local corporation. As a part of this school-business partnership, students were brought to the job site and were given the task of creating a specific machine component. Using information provided to them and generating their own information, they designed, created, and produced the new machine component and demonstrated to company officials how the product worked.

Appendix 3
Scientific Thinking Process



All scientific thinking processes can be used to some extent by all individuals at any age. However, research evidence suggests that there are periods in a student's development in which particular processes have a higher payoff for learning, and there are periods when some processes contribute little. (Lawrence Hall of Science, January, 1993)

Appendix 4
Process Skills
(Taken from the Kansas Curricular Standards in Science, 1995)

The processes of science are skills that are essential to developing knowledge, concepts, and applications across the curriculum. The processes are often referred to as the "hands-on" approach to science and must be used throughout the program. Each of the terms implies active student participation and has been adapted from the following post-Sputnik science curricula: Elementary Science Study; Science - A Process Approach; Science Curriculum Improvement Study.

Observing: Using the senses to gather information about objects and events in the environment. This skill includes using scientific instruments to extend the range of the human senses and the ability to differentiate relevant from non-relevant events.

Classifying: 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.

Measuring: A procedure for using instruments to determine the length, area, volume, mass, or other physical properties of an unknown quantity. It requires the proper use of instruments and the ability to calculate the measured results.

Using Numbers: This skill includes number sense, computation, estimation, spatial sense, and whole number operations.

Communicating: Transmitting the results of observations and experimental procedures to others through the use of such devices as graphs, charts, tables, written descriptions, telecommunications, oral presentations, etc. Communication is fundamental to science, because it is through the exchange of ideas and the results of experiments that knowledge is validated by others.

Questioning: The formulation of original questions based on observations and experiences with an event in such a way that one can experiment to seek the answers.

Relating: In the sciences, information about relationships can be descriptive or experimental. Relationships are based on logical arguments that encompass all data. Hypothetical reasoning, deductive reasoning, coordinate graphing, the managing of variables, and the comparison of effects of one variable upon another contribute to understanding the "big" ideas of science.

Inferring: An inference is a tentative explanation that is based on partial observations. Available data are gathered and a generalization is made based on the observed data. These judgments are never absolute and reflect what appears to be the most probable explanation at the time and are subject to change as new data are accumulated.

Predicting: Using previously observed information to make possible decisions about future events.

Formulating Hypotheses: Stating a probable outcome for some occurrence based on many observations and inferences. The validity of the hypothesis is determined from testing by one or more experiments.

Identifying and Controlling Variables: Determining which elements in a given investigation will vary or change and which ones will remain constant. Ideally, scientists will attempt to identify all the variables before an investigation is conducted. By manipulating one variable at a time they can determine how that variable will affect the outcome.

Collecting and Interpreting Data: The information collected in order to answer questions is referred to as data. Interpreting data includes using information to make inferences and predictions and then to form hypotheses. This includes developing skills in communicating statistical statements about the data in the form of mode, mean, median, range, and standard deviation.

Experimenting: This process is the culmination of all the science process skills. Experimentation often begins with observations which lead to questions that need answers. The steps for proceeding may include formulating a hypothesis, identifying and controlling variables, designing the procedure for conducting tests, implementing the test, collecting and interpreting the data, and sometimes changing the hypothesis being tested.

Applying: The process of inventing, creating, problem solving, and determining probabilities are applications of using knowledge to discover further information.

Constructing Models: Developing physical or mental representations to explain an idea, object, or event. Models are usually developed in the basis of acceptable hypotheses.

Appendix *5*
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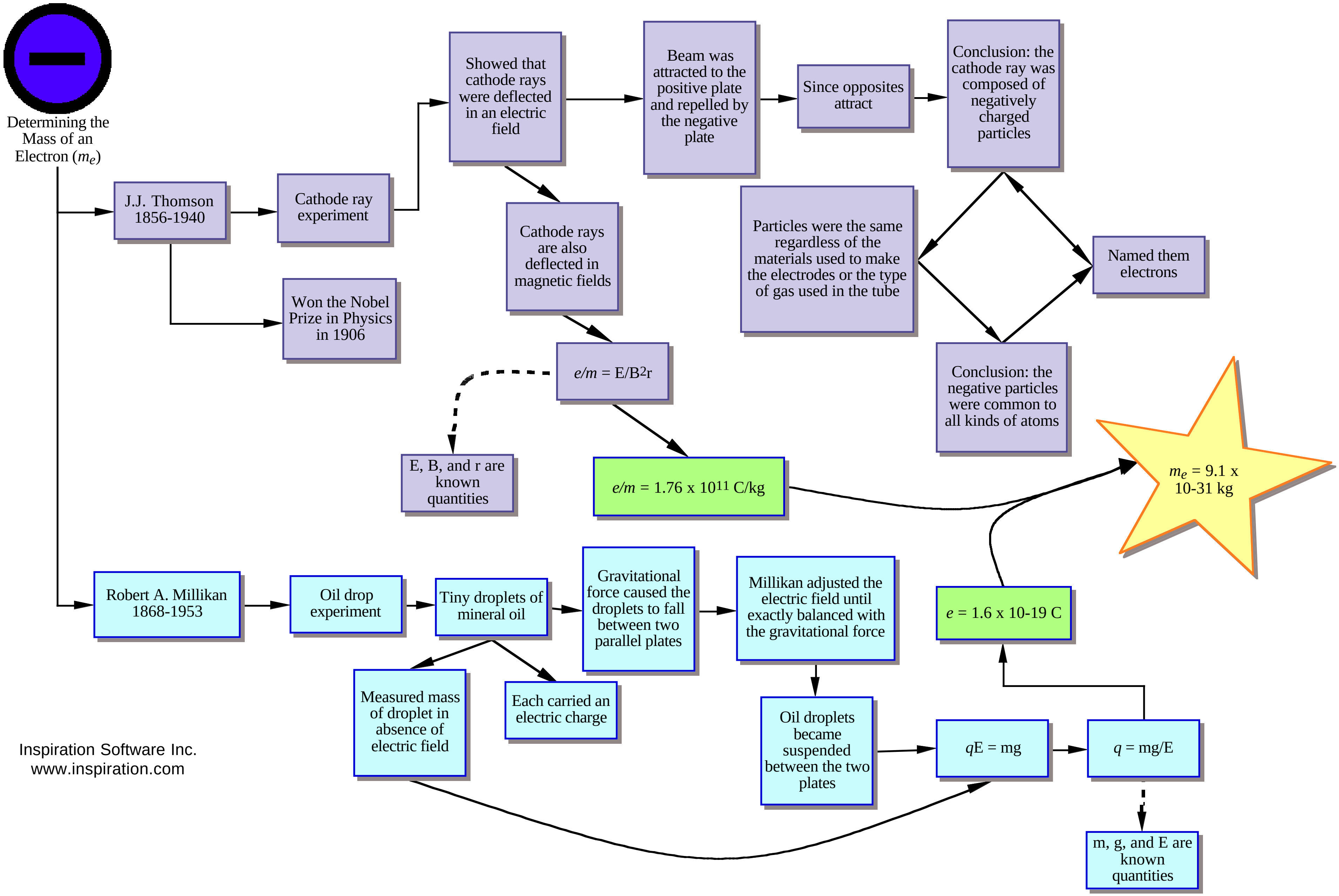

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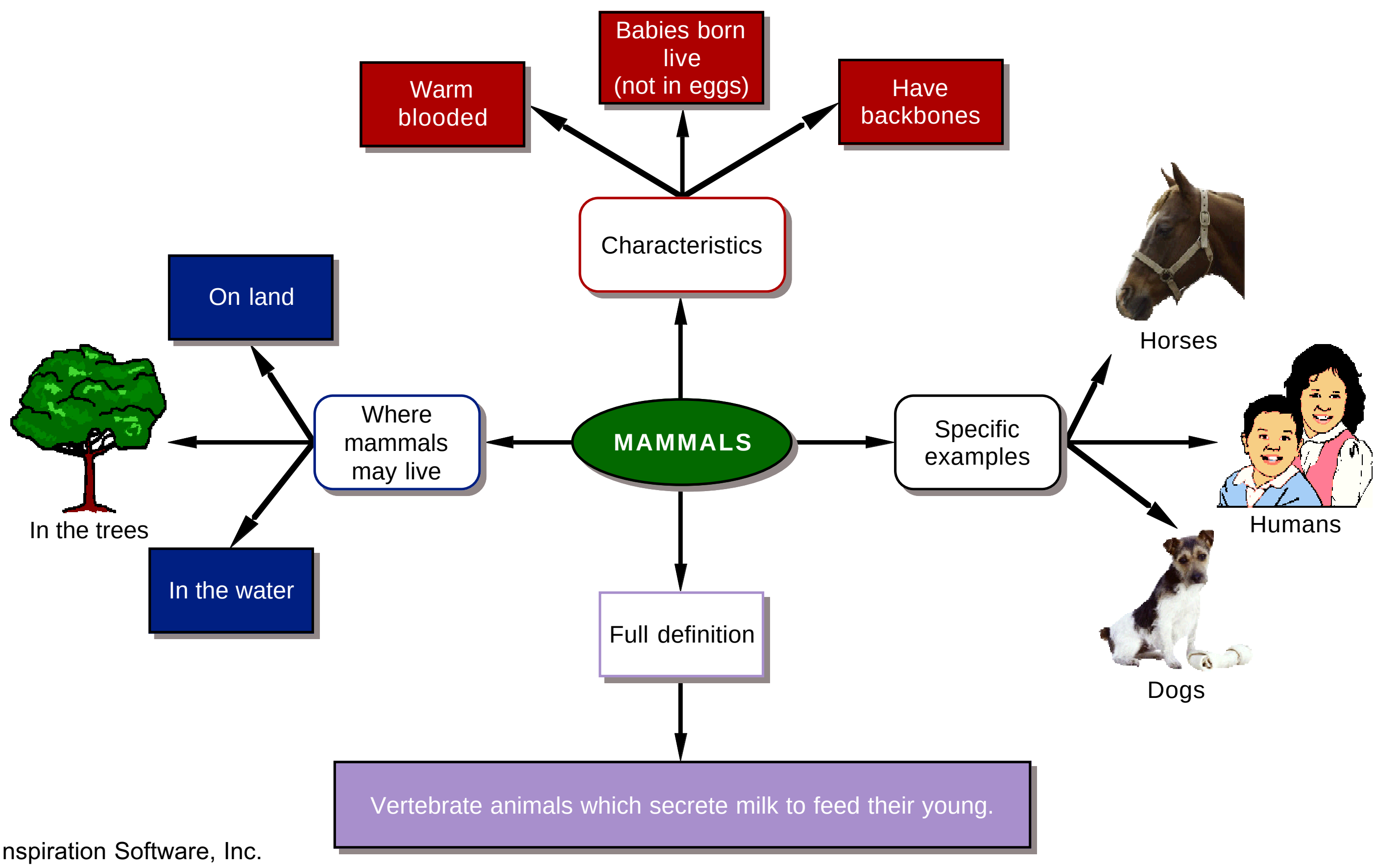

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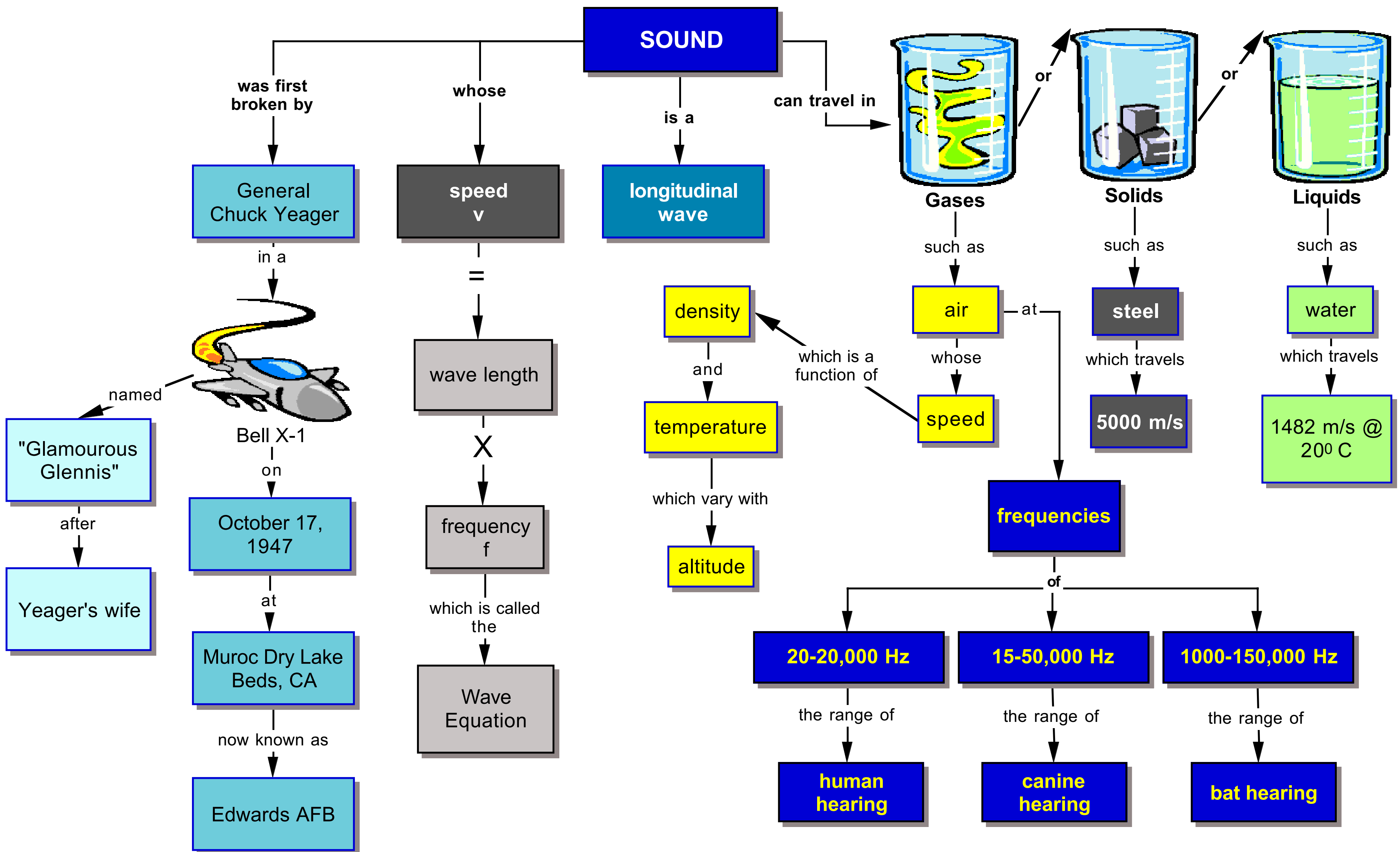

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