SCIENCE

Standard Course of Study and
Grade Level Competencies

K-12

PUBLIC SCHOOLS OF NORTH CAROLINA
State Board of Education | Department of Public Instruction

NC DEPARTMENT OF PUBLIC INSTRUCTION

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The current revision process involved on some level the entire science educational community, and its end product is a North Carolina curriculum of which North Carolina can be proud. We will regularly revise and improve the curriculum in order to meet the needs of the students of North Carolina.

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PREFACE

Intent

In a 1786 letter to a friend, Thomas Jefferson called for "the diffusion of knowledge among the people. No other sure foundation can be devised for the preservation of freedom and happiness." Jefferson saw clearly what has since become evident: that nations' fortunes rest on their citizens' ability to understand and use information about their world.

Given his life-long fascination with the natural world, Jefferson would have agreed that an understanding of science is critical to the knowledge we all need to understand and live successfully in our world. The ability to use science in turn rests on the core education that students gain from kindergarten through high school.

The science component of the North Carolina *Standard Course of Study (SCS)* was created to ensure such an education by establishing competency goals and objectives for teaching and learning science in all grades. It contains the concepts and theories, strands, skills, and processes on which all science instruction should be based. In addition, the curriculum defines and illustrates the connections between the *National Science Education Standards*, the *Benchmarks for Scientific Literacy*, and the state standards. The *SCS* is a guide to stronger, more relevant science education for every student.

Revisions

The *SCS* was last revised in 1999. The 2004 revision has been written to reflect the development of National Science Education Standards better. The 2004 revision further reflects the recommendations of the Third International Mathematics and Science Study (TIMSS) and the 1996 National Assessment of Educational Progress (NAEP) science framework and assessment. The *SCS* has been written to expand the intent of previous documents and represents an evolutionary process of curriculum refinement.

Connections

At all levels, science should be taught with an awareness of its connection to other subjects and to society's needs. As author James Burke wrote in1978, "This interdependence is typical of almost every aspect of life in the modern world. We live surrounded by objects and systems that we take for granted, but which profoundly affect the way we behave, think, work, play and in, general, conduct our lives and those of our children." The *SCS* embodies this sense of connections, as each level draws on those that precede it and contributes to those that follow.

Scope

An enormous amount of scientific content has accumulated at an increasing rate, causing curricula to thicken as material is added but rarely deleted. The science component of the *SCS*, therefore, does not include all science, but instead focuses on the fundamentals of science that all students should understand and be able to do as they move towards scientific literacy. Although the revisions suggest less coverage of some topics, they place more emphasis on teaching for understanding and the ability to apply that understanding to real life.

The Basic Educational Program for North Carolina's Public Schools specifies that *The North Carolina Standard Course of Study* is the curriculum that should be provided in all schools throughout the state. Local schools are in compliance with the *Basic Educational Plan* by providing the learning experiences as described in the *SCS*.

Underlying these standards is the principle that neither gender, nor economic status, nor cultural background limits a student's ability to understand scientific principles and develop science-related skills.

PHILOSOPHY

The science component is designed to assist educators in planning, implementing, and assessing a science program that allows "students to develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture." (National Science Education Standards, 1996, p.21) It is based on the belief that:

- Science is a human activity that can be characterized by participants' processes.
- All students can learn and succeed in science.
- Learning science is something students do, not something that is done to them.
- Everyone can describe, explain, and predict natural phenomena.
- Science, technology and society are interrelated.
- Attitudes toward science established in childhood shape adult scientific literacy.

The goal of the North Carolina Standard Course of Study is to achieve scientific literacy. The National Science Education Standards define scientific literacy as "the knowledge and understanding of scientific concepts and processes required for scientific decision making, participation in civic and cultural affairs, and economic productivity." (p. 22) The tenets of scientific literacy include the ability to:

- Find or determine answers to questions derived from everyday experiences.
- Describe, explain, and predict natural phenomena.
- Understand articles about science.
- Engage in non-technical conversation about the validity of conclusions.
- Identify scientific issues underlying national and local decisions.
- Pose explanations based on evidence derived from one's own work.

This philosophy is based on research, state and federal documents, and ideas of professional societies. Though research shows that all students can learn and succeed in science, all students will not become scientists nor achieve the same level of understanding. Rather, the goal is to create a scientifically literate society crucial to our increasingly complex and technological world. The decisions of future policy makers will, in large measure, be based on attitudes developed in today's classrooms. Research in cognitive science and science education supports the need for concept development through science and technology instruction. All students, in all grades, deserve continuing and meaningful science instruction.

PURPOSE

The science component of the North Carolina *Standard Course of Study (SCS)* is designed to provide learning opportunities for all students to become scientifically literate. Scientific literacy implies an understanding of the scientific concepts and processes needed for personal decision-making, participation in civic affairs, and economic productivity. A scientifically literate person has a substantial understanding of scientific concepts and inquiry skills, which enable one to continue to learn and think logically. This person understands and appreciates the limits of science and technology. North Carolina students can achieve scientific literacy through an instructional program based on the science component of the *SCS*. The intent of the science program is to merge unifying concepts of science, strands, content goals, and objectives.

Elementary Education

The elementary science section of the *SCS* integrates the unifying concepts of science to provide continuity in science instruction across grade levels and between science disciplines. These unifying concepts are:

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

The elementary science section of the *SCS* has four strands that provide the context for teaching the goals and objectives. The strands include:

- Nature of Science.
- Science as Inquiry.
- Science and Technology.
- Science in Social and Personal Perspectives.

By the end of fifth grade, all students should have developed an understanding of the following:

- Characteristics of organisms.
- Similarities and differences in organisms.
- Life cycles of organisms.
- Organisms and environments.
- Ecosystems.
- Properties of earth materials.
- Weather concepts.
- Objects in the sky.
- Changes in earth and sky.
- Properties of objects and materials.
- Position and motion of objects.
- Electricity, magnetism and sound.

Middle School Education

The middle school science section of the *SCS* continues to integrate the unifying concepts of science to provide continuity in science instruction across grade levels and between science disciplines. These unifying concepts are:

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

The middle school section of the *SCS* includes four strands that provide the context for teaching the goals and objectives. The strands encompass:

- Nature of Science.
- Science as Inquiry.
- Science and Technology.
- Science in Social and Personal Perspectives.

By the end of eighth grade, all students should have constructed understanding of the following concepts, theories, and universal laws:

- Human body systems.
- Basic heredity and genetics.
- Population dynamics.
- Diversity and adaptations of organisms.
- Change over time of life and landforms.
- Structure of the earth system.
- Earth in the universe.
- Transfer of energy.
- Motion and forces.
- General and interacting properties of matter.
- Basic cellular biology.

High School Education

The high school science section of the *SCS* continues to integrate the unifying concepts of science to provide continuity in science instruction across grade levels and between science disciplines. These unifying concepts are:

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

The high school science section of the *SCS* includes four strands that provide the context for teaching the goals and objectives. They are:

- Nature of Science.
- Science as Inquiry.
- Science and Technology.
- Science in Social and Personal Perspectives.

By the end of twelfth grade, all students should have constructed an understanding of the following concepts, theories, and universal laws. This understanding should result from required courses including biology, an earth/environmental science, and a physical science.

- The cell.
- Molecular basis of heredity.
- Biological evolution.
- Interdependence of organisms.
- Energy in earth systems.
- Geological cycles.
- Origin and evolution of the earth system.
- Origin and evolution of the universe.
- Structure of atoms.
- Structure and properties of matter.
- Chemical reactions.
- Motions and forces.
- Conservation of energy and increase in disorder.
- Interaction of energy and matter.

The science graduation requirements may be satisfied in a variety of ways.

Satisfaction of the biology requirement may be designed locally to encourage the study of local biological topics. Specific examples of courses that may satisfy this requirement include Standard Course of Study Biology, Advanced Placement (AP®) Biology, or IB Biology. Any locally designed course that satisfies this requirement must include all of the competency goals designated in the Biology Course in the Science Standard Course of Study. To meet the biology requirement, students must take the End-of-Course test in Biology.

Satisfaction of the earth/environmental science requirement may be designed locally to encourage the study of local earth/environmental issues. Specific examples of courses that may satisfy this requirement include: Standard Course of Study Earth/Environmental Science, AP® Environmental Science, or IB Environmental Systems. Any course that satisfies this requirement must include all of the competency goals designated in the Earth/Environmental Science course in the Science Standard Course of Study.

Satisfaction of the physical science requirement may be locally designed to encourage the study of topics of local interest in the physical sciences. Specific examples of courses that may satisfy this requirement include Standard Course of Study Physical Science, Chemistry or Physics, AP® Chemistry or Physics, and IB Chemistry or Physics. Any locally designed course that satisfies this requirement must include all of the competency goals designated in one of the following Standard Courses of Study: Physical Science, Chemistry, or Physics. Students taking a locally designed class must take one of the corresponding End-of-Course tests to meet the physical science requirement, with the exception of Principles of Technology I and Principles of Technology II.

In addition, Principles of Technology I or Principles of Technology II can count as the physical science credit required for graduation under these conditions:

- When PT I is taken to meet the physical science requirement, students must take the PT I postassessment. When PT I is counted as the Physical Science course, students are subject to the End-of-Course test for physical science.

- When PT II is taken to meet the physical science requirement, students must take the PT II postassessment. PT II (with PT I as a prerequisite) may count as the course Physics. When PT I and II are counted as the course, Physics, students in this course are subject to the End-of-Course Test in physics.

PT I and PT II may count as the physical science credit required for admission to the University of North Carolina System Institutions when the student has taken the career technical postassessment.

For students in the occupational course of study, two years of Life Skills Science satisfy the science graduation requirement. These courses of study are available through the Exceptional Children's Division at the North Carolina Department of Public Instruction.

High School Science Sequences

A wide variety of high school science course sequences may be used to meet the needs of individual students, schools and districts. Traditionally no one sequence has been recommended because the sciences have been treated as separate disciplines. Currently there is disagreement among scientists and science educators about which sequences are best. Neither *Benchmarks for Science Literacy* (American Association for the Advancement of Science - Project 2061, 1993) nor the *National Science Education Standards* (National Research Council, 1996) recommend a particular sequence, although both recommend that curriculum materials and teachers make more connections between different science disciplines and between the sciences and other disciplines. North Carolina does not have a required sequence because the *K-8 Standard Course of Study* should prepare students to take any of the standard level high school science courses.

Some typical sequences follow; however, other sequences are possible to meet the needs of particular schools and students. For example, in some smaller schools, Physics and Chemistry are offered in alternate years due to the small number of students and or limited teacher availability. In all recommended sequences, students may take AP or IB Biology, Chemistry, or Physics in lieu of the corresponding SCS course. In many cases, students take additional science electives such as Human Anatomy and Physiology, Astronomy, and AP and IB science courses.

Sequence 1

9^{th}	Biology
10^{th}	Chemistry
11^{th}	Physics
12^{th}	AP Environmental Science

This sequence allows students to meet both North Carolina graduation requirements and the North Carolina Academic Scholar requirements. It follows the recommendation of some universities that students, particularly those planning to major in the natural sciences, should take both chemistry and physics. It also allows students to gain an AP credit while meeting the North Carolina earth/environmental science requirement. With rising expectations in science and mathematics at the middle school level, it should be expected that more students will be capable of completing a sequence including both a chemistry and physics course.

Sequence 2

9th	Earth/Environmental
10th	Biology
11th	Physical Science or Chemistry or Physics
12th	Chemistry or Physics or a science elective

This sequence allows teachers to design a concrete and inquiry oriented Earth/Environmental Science course to introduce students to high school science. Further, students have the opportunity to take both a chemistry course and a physics course if desired.

Sequence 3

9th	Earth/Environmental
10th	Biology
11th	Principles of Technology I
12th	Principles of Technology II

This sequence allows the student to use career-technical education courses to meet the University of North Carolina admissions requirement for a physical science course. Principles of Technology I and II have been designed to give a rigorous hands-on approach to the development of physical science concepts.

Sequence 4

9th	Earth/Environmental
10th	Physical Science
11th	Biology
12th	Chemistry or Physics or a science elective

This sequence retains the advantage of allowing teachers to design a concrete and inquiry oriented Earth/Environmental Science course to introduce students to high school science. This may be followed by a strong physical science course to build the foundation for a more rigorous and molecularly oriented biology course. Students complete their science graduation requirement by the end of the 11th grade and have room to take Chemistry or Physics or other science elective course in the 12th grade. The disadvantage of this sequence is that, unless students take more than one science in a year, they will not have the opportunity to take both a chemistry course and a physics course.

Sequence 5

9^{th}	Physical Science
10^{th}	Biology
11^{th}	Earth/Environmental or AP Environmental
12^{th}	Chemistry or Physics or science elective

This sequence allows the development of physical science concepts before biology, thus preparing students to better understand modern cellular and molecular biology. The disadvantage of this sequence is that, unless students take more than one science in a year, they will not have the opportunity to take both a chemistry course and a physics course.

DESCRIPTION OF PROGRAM STRANDS

Nature of Science

The Nature of Science strand allows us to see science as a human endeavor. Women and men of various backgrounds, with diverse interests and motives, are involved in science, engineering, and related fields. While science encompasses many disciplines, such as physics, chemistry, biology, and the geosciences, these disciplines often take different approaches to the study of natural phenomena.

There also are different ways to define science. A lay person might see it as a body of information, a scientist might define it as set of procedures by which hypotheses are tested, and a philosopher might regard it as a way to question the truth of what we know. Each of these views is a valid, but only partial, definition of science. Collectively, however, these concepts begin to define the comprehensive nature of science, which is why a comprehensive science program should include inquiry, as well as the skill-building investigations that demonstrate universal laws of science. (Chiappetta et. al., 1998)

Science is a way of knowing about the world. In science, explanations are limited to those that can be inferred from confirmable data - the results obtained through observations and experiments that can be substantiated by other scientists. (National Academy of Sciences, 1986, p. 27) When observations of a phenomenon have been confirmed or can be repeated, they are regarded as fact. Any scientific confirmation is, however, tentative, because it is always possible that the results occurred by chance.

A scientific theory is an explanation based on a body of continually refined observation, inference, and testable hypotheses. Because science is never irrevocably committed to any theory, no matter how firmly it appears to be established, science is not dogma. Any theory is always subject to change in the light of new and confirmed observations. Students should be taught that uncertainty is not a weakness, but a strength that leads to self-correction.

History provides yet another way to understand how science works. Students should learn that much of the progress in science and technology is the result of a gradual accumulation and application of knowledge over many centuries. (American Association for the Advancement of Science (AAAS), 1993)

Engaging Science

Above all, the pursuit of science should be fun and exciting. Educators can capitalize on children's natural curiosity and the joy they experience "doing" science. Put the "wow" into science education, and students' attention is almost guaranteed.

It was a strange sight: a man, standing before a fountain, watching the falling water and tilting his head from side to side. Drawing closer, I saw he was rapidly moving the fingers of his right hand up and down in front of his face.

I was in the seventh grade, visiting Princeton University with my science class, and the man at the fountain was Albert Einstein.

For several minutes, he continued silently flicking his fingers. Then he turned and asked, "Can you do it? Can you see the individual drops?"

Copying him, I spread my fingers and moved them up and down before my eyes. Suddenly, the fountain's stream seemed to freeze into individual droplets. For some time, the two of us stood there perfecting our strobe technique. Then, as the professor turned to leave; he looked me in the eye and said, "Never forget that science is just that kind of exploring and fun." (Rowe, 1995, p. 177)

Science As Inquiry

Students cannot just read and/or be told about science -- they must do science. All students should experience the excitement of science as they try to understand the natural world. Science experiences should also connect students to everyday life and the science- and technology-related social issues with which local communities, nations, and all humanity struggle (Creed, et. al. 1992; Aikenhead and Solomon, 1994).

The revised North Carolina Standard Course of Study takes students beyond science as merely a body of knowledge to science as inquiry. It requires students to combine science and scientific knowledge with scientific reasoning and critical thinking. Engaging students in scientific inquiry helps them develop:

- An understanding of scientific concepts.
- An appreciation of how we know what we know in science.
- An understanding of the nature of science, along with the skills to become independent discoverers of the natural world.
- The disposition to use the skills and attitudes associated with science.

Science as inquiry is key to organizing and guiding students' activities. Students in all grades and in every scientific discipline should have the opportunity ask questions, plan and conduct investigations, use appropriate tools and techniques to gather data, think critically and logically about relationships between evidence and explanations, and communicate arguments.

With increasing emphasis on experiential learning, we also must teach appropriate safety practices when engaging in any science activity. Teachers must be aware of safety recommendations, regulations, and laws relating to topics such as eye safety, use of chemicals, and field trip behavior. When students and teachers know how to do science safely, such concerns should not deter meaningful learning activities.

An effective science program provides ample opportunities for students to:

- Apply safe laboratory/manipulative procedures.
- Choose, construct, and/or assemble appropriate equipment.
- Manipulate materials, scientific equipment and technologies.
- Properly handle and care for living organisms, materials, and equipment.

If students are to understand the scientific process, they must make decisions themselves. Time must be allowed for revision and repetition of experiments, presentation of results, and even for response to criticism. Inquiry-based programs lead to integrated studies because students seldom take divisions among disciplines very seriously. Students who learn to question, debate, and explore acquire a deeper understanding of the world. By discovering principles, rather than just memorizing them, students learn not just what we know, but how we know it, and why it is important.

"Science is a way to teach how something gets to be known, to what extent things are known (for nothing is known absolutely), how to handle doubt and uncertainty, what the rules of evidence are, how to think about things so that judgments can be made, how to distinguish truth from fraud and from show." (Fyneman, 1969)

Teaching Inquiry

Different scientific disciplines use various methods and theories to advance knowledge. Investigations may involve discovering, observing and describing objects, organisms or events. They also may involve experiments, a search for more information, or model making. To help focus investigations, students should frame questions, such as "What do we want to find out?" "How can we make the most accurate observations?" and "If we do this, what do we expect will happen?" Scientific inquiry should involve students in establishing and refining the methods, materials, and data to collect. As students investigate and observe, they should consider questions such as "What data will answer the question?" and "What are the best measurements to make?"

New knowledge and methods emerge from these investigations and from interaction. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections among natural phenomena, investigations, and scientific knowledge. In addition, the methods and procedures used to obtain evidence must be clearly reported to encourage further investigation.

Science advances through legitimate skepticism. To evaluate explanations proposed by others, scientists examine and compare evidence, identify faulty reasoning and statements that go beyond the evidence, and suggest alternative explanations. Scientific explanations must be logically consistent, based on historical and current scientific knowledge, and open to question and modification. Students, therefore, should be encouraged to present the results of their inquiries in oral or written reports. Student discussions should center on questions, such as "How should we organize the data to present the clearest answer to our question?" Out of the discussions about the ideas, the background, and the data, learners will gain experience in the practice of science and scientific thought.

Science and Technology

A single problem often has both scientific and technological aspects. For example, investigating the salinity of the water in North Carolina's sounds is science, while creating a way to make this salt water drinkable is technology. In other words, while science tries to understand the natural world, technology tries to solve practical problems. Technology expands our capacity to understand and control the natural and human-made environment.

"Technology" has many definitions. It may, for example, denote a way of doing things, and/or a specific object. Stephen Kiln, Professor of Mechanical Engineering at Stanford University has four definitions of technology (Kiln, 1985):

- Artifact or hardware (e.g., an aspirin, chair, or video tape).
- Methodology or technique (e.g., painting, using a microscope).
- System of production (e.g., the automobile assembly line, a process for manufacturing a product or an entire industry).
- Social-technical system (an airplane, for example, suggests a plethora of interrelated devices, human resources, and artifacts such as airports, passengers and pilots, fuel, regulations and ticketing).

Science and Technology in Society

"Achieving the goal of scientific and technological literacy requires more than understanding major concepts and processes of science and technology. Indeed, there is a need for citizens to understand science and technology as an integral part of our society. Science and technology are enterprises that shape and are shaped by human thought and social actions." (Bybee and DeBoer, 1994, p. 384)

Technology has always played a role in the growth of scientific knowledge. The techniques for shaping, producing or manufacturing tools, for example, are the primary evidence of the beginning of human culture.

Science and technology also reflect a culture's values. Consider, for example, how the acceptance of new ideas can be constrained by the environment in which they are conceived. Galileo's efforts to change perceptions of Earth's place in the solar system, Newton's demonstrations of the laws of motion, and Pasteur's identification of infection with microscopic organisms were rejected by the scientific establishment of their times. Only because of contributions from later investigators did they slowly achieve acceptance.

The development of technology also has been crucial to economic growth. For example, in an effort to make the 1890 U.S. Census faster and more efficient, Herman Hollerith drew upon early "counting machines" to develop a prototype of the computer, which in turn has created today's high-tech industries. In the words of C. Purcell (1995, p. xii) "Since individual technologies and their networks enhance or undermine the people we want to be and the society in which we want to live, we as citizens must try to understand this mighty force and see it not only for what it is but also for what it might be."

While properly applied technology will continue to benefit humanity, we must be aware that its misuse can harm the environment and jeopardize human well-being. Responsibility and stewardship are basic to teaching and learning science and technology. Students must understand that scientific and technological discoveries may have complex -- and perhaps unanticipated -- repercussions that must be addressed.

Technology As Design

Technology as design is analogous to science as inquiry.
All students should engage in problem-solving by designing, building, and testing solutions to real-world problems. By applying critical thinking skills and knowledge of materials, learners can compare and assess technological devices for costs, benefits, applications, practicality, environmental impact, safety, and convenience.

The goals and objectives for technological design call for students to accumulate the skills necessary to:

- Identify and state a problem, need, or product
- Design a solution including cost and risk/benefit analysis
- Implement and evaluate the solution
- Accurately record and communicate observations.

Today's technology provides nearly instant access to a storehouse of information. Students must learn to use technology as a tool to help understand science and increase creativity in scientific investigations.

Science in Personal and Social Perspectives

An essential component of balanced science education is the use of scientific conceptual understandings and processes in personal and public decision-making. Science education gives students a means to understand and act on such issues. In addition, we are so dependent on science and technology that progress is almost universally identified with them. Students must therefore develop a basic understanding of science and technology in order to become responsible citizens capable of making decisions on social, technological, environmental and other problems faced by their communities and throughout the world.

The ability to understand the nature of science and technology, to apply the concepts of and theories about the earth and life, and to use inquiry and technological design in making personal and societal decisions should be the culmination of a K-12 science education. The challenge of science education is to prepare students to be scientifically and technologically literate decision-makers and problem solvers.

UNIFYING CONCEPTS OF SCIENCE

Students are naturally curious about the world and their place in it. Sustaining this curiosity and giving it a scientific foundation must be a high priority in North Carolina schools. Students need to be actively involved in scientific investigations, develop a rational and objective framework for solving problems, and understand the concepts that unify the various fields of science. Science is not a mandate for rote memorization, nor a dormant collection of facts. Students should not simply be shown results or text or pictures about science. Instead they need to learn that science produces a dynamic, constantly expanding body of knowledge developed over time. Students should discover by their own experiences that science is a process of gathering and evaluating information, looking for patterns, and then devising and testing possible explanations based on actual evidence.

The science component of the North Carolina *Standard Course of Study* bases its goals and objectives on the unifying concepts of science as described in the *National Science Education Standards*. The use of unifying concepts is an effective way to create linkages within and among fields of science such as physics and biology. These key ideas underlie and integrate all scientific knowledge and connect with other disciplines such as mathematics and social studies. Consequently, the focus on unifying concepts helps students to construct a holistic understanding of science and its role in society. The application of these concepts provides students with productive and insightful ways of considering and integrating a range of basic ideas that help to explain the natural and designed world.

Unifying concepts help students organize their thinking about science. By understanding these concepts and using them as they explore science, students will learn to see the broad patterns that cut across all science fields. Unifying concepts should be emphasized continuously in the context of topics included in the goals and objectives from grades K-12. Constant references to, and active use of, these ideas will help students understand the unifying concepts. The unifying concepts then provide a lens through which students can focus their scientific thinking.

Unifying concepts, as identified by the *National Science Education Standards*, include the following:

- **Systems, order and organization-** An important part of understanding and interpreting the world is the ability to think about the whole in terms of its parts and, alternatively, about parts as they relate to one another and to the whole. Science shows that there is order and predictability in nature. Understanding the basic laws, theories, and models that explain the world can be accomplished by connecting order and organization to systems. Students should study both natural and technological systems.

- **Evidence, models and explanation-** Students should have science experiences and a learning environment which encourage the quest for evidence. Evidence is defined by the *National Science Education Standards* as observations and data on which to base scientific explanations. Models are used to explain events which may or may not be directly observable. Models consist of physical objects or mathematical representations. Computer models are often constructed to simulate complex systems and to visualize data. Explaining in a scientifically literate manner consists of considering and evaluating new evidence in the light of existing knowledge. The national standards state that scientific explanations should be based on a scientific knowledge base and an understanding of the relationship among logic, evidence, and current knowledge.
- **Change, constancy and measurement-** The concepts of constancy and change underlie most understandings of the natural and technological world. Through observations, students learn that some characteristics of living things, materials, and systems remain constant over time, whereas others change. Through formal and informal studies, students develop an understanding of the processes and conditions in which change, constancy, and equilibrium take place. Change in systems can be quantified. Students should apply mathematical skills of accuracy, precision, scale, rate, and appropriate systems of measurement.
- **Evolution and equilibrium-** Evolution represents change in systems. Systems may be biological, physical, or technological. Geological systems include chemical, physical and biological processes. Change may be abrupt or occur over various lengths of time. As systems react to forces and change, a state of equilibrium may develop where forces and changes occur in opposite and off-setting directions.
- **Form and function-** As students analyze natural and technological systems, the form of sub-units of systems or entire systems should be explained in terms of function. Students should be able to explain form and function and how the two are interrelated.

Because the understanding and abilities associated with major conceptual and procedural schemes need to be developed over an entire educational experience, unifying concepts transcend disciplinary boundaries. The science standards are organized with the expectation that science-related activities occur at all grade levels--from initial explorations in kindergarten through increasingly organized and focused science investigations in higher grades--and that science is taught in conjunction with all other subject areas. Unifying concepts of science provide the basis for integration of the fields of science. The methods and thought processes of science have application well beyond the bounds of science and can support the broader goals of all subject areas.

Early Grades K-5

The elementary science section of the *SCS* integrates the unifying concepts of science to provide continuity in science instruction across grade levels and among science disciplines. These unifying concepts are:

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

The elementary science section of the *SCS* strands provides unifying threads of understanding that span the content areas of elementary science. The strands include the following goals:

Nature of Science

As a result of activities in grades K-5, all students should develop an understanding of:

- Science as a human endeavor.
- Science as inquiry.
- The nature of scientific inquiry.

Science as Inquiry

As a result of activities in grades K-5, all students should develop:

- Abilities necessary to do scientific inquiry.
- Abilities necessary to understand, to use, and to apply the unifying concepts and processes of science including:
  - evidence, explanation, measurement.
  - ordering, organizing.
  - changes (time, rate, scale, patterns, trends, cycles).
  - Systems.
    - boundaries.
    - components.
    - resources.
    - flow.
    - feedback.
  - form, function, equilibrium.
  - models.

Science and Technology

As a result of activities in grades K-5, all students should develop:

- Ability to use and create technological designs.
- Understanding about technology and design.
- Ability to distinguish between natural and human made objects.

Science in Personal and Social Perspectives

As a result of activities in grades K-5, all students should develop understanding of:

- Impacts of science and technology on their daily lives.
- The relationship of science to personal health and welfare.
- Characteristics of and changes in populations.
- Applications of science and technology to local challenges.

KINDERGARTEN

Goal

Students in kindergarten begin their science studies using their five senses to observe animals, earth materials, weather, and other objects. The class setting should provide a stimulating atmosphere in which students are intellectually challenged to explore the physical world around them. Young students' natural curiosity leads them to investigate the world by observing and manipulating common objects and materials in their environment. Students learn to interpret their observations by collecting data on which they base their scientific explanations. Student learning of all four goals is guided by the unifying concepts of evidence, exploration, and measurement.
The following explanations characterize the strands at the kindergarten level.

Nature of Science

The Nature of Science Strand is designed to help students develop an understanding of the human dimensions of science, the nature of scientific thought, and the role of science in society. Science education in kindergarten serves as the earliest foundation for students to experience science in a form that engages them in active construction of ideas and explanations. Young students always have questions about themselves and their world. Science is one way of finding answers to their questions and enabling them to make sense of the natural world. Teaching science as inquiry increases students' opportunities to develop the abilities to do science. Their natural curiosity leads them to explore the world by observing and manipulating common objects and materials in their environment. They make observations using their senses to collect data and to obtain evidence for their scientific explanations.

Science as Inquiry

Research shows that young students work well in small groups or pairs to construct and share ideas. Students in kindergarten should employ simple equipment and tools to gather data and extend their senses. Students develop simple skills such as how to observe, measure using(non-standard)units, use numbers, sort (using own rules) cut, connect, switch, turn on and off, pour, hold, tie, and hook.

They begin to ask questions that they can answer with scientific knowledge combined with their own observations and simple predictions. In the earliest years, investigations are largely based on systematic observations. Through the observation and manipulation of common objects students reflect on their similarities and differences. This leads to simple sketches and single-word descriptions which in turn lead to increasingly more detailed drawings, richer verbal descriptions, and connections to writing.

Science and Technology

Young students' abilities in technological problem-solving can be developed by first hand experiences in doing tasks with a technological purpose. They can study technological products and systems in their world, such as zippers, coat hooks, can openers, tricycles and other tools. Students can engage in projects that are appropriately challenging for their developmental level, ones in which they must design ways to connect, move, or communicate.

Personal and Social Perspectives

Students in kindergarten should have a variety of experiences that provide initial understandings for personal care and that enable them to take responsibility for their own health. Student understandings should include following safety rules for all their school experiences as well as at home, preventing abuse and neglect, avoiding injury, and when and how to say no.

Science – Kindergarten

The focus for kindergarten students is on using the five senses to make observations of events in both indoor and outdoor settings that make up their world. The observations that students make provide evidence and data on which to base their scientific explanations. Guide student learning of all goals on the unifying concepts of evidence, explanation, and measurement. The strands provide a context for teaching the content throughout all goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives

COMPETENCY GOAL 1: The learner will make observations and build an understanding of similarities and differences in animals.

Objectives

1.01 Observe and describe the similarities and differences among animals including:
- Structure.
- Growth.
- Changes.
- Movement.

1.02 Observe how animals interact with their surroundings.

1.03 Observe the behaviors of several common animals.

1.04 Demonstrate how to care for a variety of animals.

1.05 Observe the similarities of humans to other animals including:
- Basic needs.
- Growth and change.
- Movement.

COMPETENCY GOAL 2: The learner will make observations and build an understanding of weather concepts.

Objectives

2.01 Observe and report daily weather changes throughout the year.

2.02 Identify different weather features including:
- Precipitation.
- Wind.
- Temperature.
- Cloud cover.

2.03 Identify types of precipitation, changes in wind, force, direction and sky conditions.

2.04 Observe and determine the effects of weather on human activities.
2.05 Use common tools to measure weather.

COMPETENCY GOAL 3: The learner will make observations and build an understanding of the properties of common objects.

Objectives

3.01 Observe and describe the properties of different kinds of objects (clay, wood, cloth, paper, other) and how they are used.
3.02 Develop and use a vocabulary associated with the properties of materials:
- Color.
- Size.
- Shape.
- Texture.

3.03 Describe how objects look, feel, smell, taste, and sound using their own senses.
3.04 Observe that objects can be described and sorted by their properties.
3.05 Identify some common objects and organisms that are considered to be natural resources in our world.

COMPETENCY GOAL 4: The learner will use appropriate tools and measurements to increase their ability to describe their world.

Objectives

4.01 Describe how tools can be used to make comparisons.
4.02 Observe and describe how various tools and units of measure are useful:
- Scissors.
- Pencils.
- Crayons.
- Paper clips.
- Hammers.

4.03 Use nonstandard units of measure to describe and compare objects.
4.04 Demonstrate the use of standard units of measure and compare with nonstandard units of measure. (Teacher demonstration)
4.05 Demonstrate that standard units of measure produce more consistent results than nonstandard units, allowing information to be shared.(Teacher demonstration)

GRADE ONE

Goal

Science education in first grade extends the foundation that began in kindergarten with the unifying concepts of evidence, explanation and measurement and begins to add order and organization as students devise their own rules to classify living and nonliving objects. Teachers build on students' natural inclination to ask questions and investigate common objects in the natural world. Students engage in active construction of ideas and explanations as they observe, collect data, and classify, to provide types and levels of order and organization to their ideas about science concepts. The following explanations characterize the strands at the first grade level.

Nature of Science

The Nature of Science Strand is designed to help students develop an understanding of the human dimensions of science, the nature of scientific thought, and the whole of science in society. Science is one way of finding answers to students’ questions and enabling them to make sense of the natural world. Teaching science as inquiry enhances students’ opportunity to develop the abilities to do science. Students are introduced to examples of women and men who have made contributions to science, showing students how scientists work, and the importance of diversity in science and technology.

Science as Inquiry

First grade science students employ simple equipment and tools to gather data and extend their senses. Students acquire simple skills such as how to observe, measure, connect, record and report data, and to classify objects using their own rules. From their own observations, they begin to ask questions and make predictions. Students’ investigations are largely based on systematic observations and simple classifications to bring order and organization to their understanding. As students develop concepts and vocabulary from such experiences, they develop the ability to ask meaningful questions, investigate aspects of the world around them, and use their observations to construct reasonable explanations for their questions.

Science and Technology

Students develop abilities to work individually and collaboratively and to use suitable tools and measurements as appropriate. Students' abilities in technological problem-solving are developed by first hand experiences in doing tasks with an identified technological purpose. They study technological tools and systems as they investigate living and nonliving objects. Students gain the ability to explain a problem in their own words and identify a specific way to find a solution appropriate to the problem.

Personal and Social Perspectives

First grade students should have a variety of experiences that provide initial understandings of personal safety that enable them to take responsibility for their own safety. They should identify and follow simple safety rules while in school and at home. Students understand that resources are found in the living and nonliving environment.

Science – Grade 1

The focus for first grade is on students using their senses to make observations and using their own rules to classify living and nonliving objects. Identifying types and levels of organization helps students find useful ways of describing objects and organisms. Guide student learning to continue to emphasize the unifying concepts introduced in kindergarten, including evidence, explanation and measurement as well as the introduction at grade one of order and organization. The strands provide a context for teaching the content goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives

COMPETENCY GOAL 1: The learner will conduct investigations and make observations to build an understanding of the needs of living organisms.

Objectives

1.01 Investigate the needs of a variety of different plants:
- Air.
- Water.
- Light.
- Space.

1.02 Investigate the needs of a variety of different animals:
- Air.
- Water.
- Food.
- Shelter.
- Space.

1.03 Observe the ways in which humans are similar to other organisms.

1.04 Identify local environments that support the needs of common North Carolina plants and animals.

1.05 Discuss the wide variety of living things on Earth.

COMPETENCY GOAL 2: The learner will make observations and use student-made rules to build an understanding of solid earth materials.

Objectives

2.01 Describe and sort a variety of earth materials based on their properties:
- Color.
- Hardness.
- Shape.
- Size.

2.02 Describe rocks and other earth materials in more than one way, using student-made rules.

2.03 Observe the various components that combine to make soil.
2.04 Compare the components of soil samples from different places.
2.05 Explore where useful earth materials are found and how they are used.

COMPETENCY GOAL 3: The learner will make observations and conduct investigations to build an understanding of the properties and relationship of objects.

Objectives

3.01 Describe the differences in the properties of solids and liquids.
3.02 Investigate several ways in which objects can be described, sorted or classified.
3.03 Classify solids according to their properties:
- Color.
- Texture.
- Shape (ability to roll or stack).
- Ability to float or sink in water.

3.04 Determine the properties of liquids:
- Color.
- Ability to float or sink in water.
- Tendency to flow.

3.05 Observe mixtures including:
- Solids with solids.
- Liquids with liquids.
- Solids with liquids.

COMPETENCY GOAL 4: The learner will make observations and conduct investigations to build an understanding of balance, motion and weighing of objects.

Objectives

4.01 Describe different ways in which objects can be moved.
4.02 Observe that movement of an object can be affected by pushing or pulling.
4.03 Investigate and observe that objects can move steadily or change direction.
4.04 Observe and describe balance as a function of position and weight.
4.05 Describe and observe systems that are unstable and modify them to reach equilibrium.

GRADE TWO

Goal

Science education in the second grade builds on the unifying concepts previously introduced in kindergarten and first grade including the use of evidence, explanation, measurement, order and organization. Second graders are introduced to changes through the study of animal life cycles, weather, properties of materials, and sound. Changes vary in rate, scale, and pattern.
The following explanations characterize the strands at the second grade level.

Nature of Science

The Nature of Science Strand is designed to help students develop an understanding of the human dimensions of science, the nature of scientific thought, and the enterprise of science in society. Teachers should emphasize experiences of investigating and thinking about explanations. Students using a cooperative learning approach can conduct simple investigations and present their findings to their classmates. They discover that humans have learned much about processes in nature but much more remains to be understood. They learn that our knowledge of science is constantly growing and will never be complete.

Science as Inquiry

Teaching science as inquiry provides teachers the opportunity to develop students' abilities and to enrich student understanding of how things change. As students focus on the study of life cycles, changes in weather, changes in properties, and changing sounds, they develop the ability to ask scientific questions, investigate aspects of the world around them, and use their findings to construct reasonable explanations for the questions posed. Inquiry involves asking a simple question, conducting an investigation, recording and analyzing results, answering the question, and communicating the results to others. By engaging in such activities, students begin to develop the physical and intellectual abilities of scientific inquiry.

Science and Technology

Students develop the ability to explain a problem in their own words, identify a specific task, and conduct an appropriate investigation. Students develop abilities to work individually and collaboratively to use suitable tools and measurements as appropriate. Tools help students make better observations and measurements in their investigations. They help students see, measure, and do things that they could not otherwise observe, measure, and do. Student abilities gained include oral, written, and pictorial communication of designs, processes, and products. The science/technology connection is one way of answering questions and explaining changes in the natural world.

Personal and Social Perspectives

Second grade students have a variety of experiences that provide initial understandings of personal safety and which enable them to take responsibility for their own safety. They identify and follow simple safety rules while in school and at home. Students' understandings should include the idea that some environmental changes occur slowly and others occur rapidly. Students should discover the different consequences of environments changing in small increments over long periods as compared with environments changing in large increments over short periods.

Science – Grade 2

The focus for second grade students is on analyzing collected data over a period of time to make predictions and understand changes. Changes vary in rate, scale, and pattern, including trends and cycles. Changes in systems can be measured. Guide student learning to continue to emphasize the unifying concepts previously introduced, including evidence, explanation, measurement, order, and organization as well as the introduction at grade two of change. The strands provide a context for teaching the content goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives

COMPETENCY GOAL 1: The learner will conduct investigations and build an understanding of animal life cycles.

Objectives

1.01 Describe the life cycle of animals including:
- Birth.
- Developing into an adult.
- Reproducing.
- Aging and death.

1.02 Observe that insects need food, air and space to grow.

1.03 Observe the different stages of an insect life cycle.

1.04 Compare and contrast life cycles of other animals such as mealworms, ladybugs, crickets, guppies or frogs.

COMPETENCY GOAL 2: The learner will conduct investigations and use appropriate tools to build an understanding of the changes in weather.

Objectives

2.01 Investigate and describe how moving air interacts with objects.

2.02 Observe the force of air pressure pushing on objects.

2.03 Describe weather using quantitative measures of:
- Temperature.
- Wind direction.
- Wind speed.
- Precipitation.

2.04 Identify and use common tools to measure weather:
- Wind vane and anemometer.
- Thermometer.
- Rain gauge.

2.05 Discuss and determine how energy from the sun warms the land, air and water.

2.06 Observe and record weather changes over time and relate to time of day and time of year.

COMPETENCY GOAL 3: The learner will observe and conduct investigations to build an understanding of changes in properties.

Objectives

3.01 Identify three states of matter:
- Solid.
- Liquid.
- Gas.

3.02 Observe changes in state due to heating and cooling of common materials.

3.03 Explain how heat is produced and can move from one material or object to another.

3.04 Show that solids, liquids and gases can be characterized by their properties.

3.05 Investigate and observe how mixtures can be made by combining solids, liquids or gases and how they can be separated again.

3.06 Observe that a new material is made by combining two or more materials with properties different from the original material.

COMPETENCY GOAL 4: The learner will conduct investigations and use appropriate technology to build an understanding of the concepts of sound.

Objectives

4.01 Demonstrate how sound is produced by vibrating objects and vibrating columns of air.

4.02 Show how the frequency can be changed by altering the rate of the vibration

4.03 Show how the frequency can be changed by altering the size and shape of a variety of instruments.

4.04 Show how the human ear detects sound by having a membrane that vibrates when sound reaches it.

4.05 Observe and describe how sounds are made by using a variety of instruments and other “sound makers” including the human vocal cords.

GRADE THREE

Goal

Third grade continues to use the unifying concepts taught in grades K-2 including evidence, explanation, measurement, order and organization, and change. Students at third grade focus on the study of systems as their unit of investigation. They learn that a system is an interrelated group of objects or components that form a functioning unit. The natural and human designed world is complex; it is too large and complicated for students to investigate and comprehend all at once. The third grade program allows students to identify small components of a system for in-depth investigation. Each investigational unit addresses a particular system. Plants, soils, earth/moon/sun, and the human body are each investigated as systems. The following explanations characterize the strands at the third grade level.

Nature of Science

The Nature of Science Strand helps students understand the human dimensions of science, the nature of scientific thought, and science's role in society. Students develop an understanding of patterns in systems, which in later grades allows them to understand basic laws and theories that explain how things work in the world. Teachers build on students' natural inclination to ask questions and investigate their world. Cooperative groups of students conduct investigations that begin with a question and progress toward finding and communicating an answer. Stories, films, videos, and multimedia resources introduce women and men from diverse groups who have contributed to science. These examples highlight how scientists work, showing how they pose and answer questions, the procedures they use, and their contributions to science, technology, and society.

Science as Inquiry

Students experience science in a way that engages them in active building of ideas and explanations, and gives them more opportunities to develop the ability to do science. Teaching science as inquiry requires a learning environment that engages students in hands-on activities and investigations. For example, if students ask each other how plants can survive in a particular environment, they might want to identify and compare the various environments where plants naturally occur. To develop the ability to do scientific inquiry, students plan and conduct a simple investigation, use simple equipment and tools to gather data, use data to construct reasonable explanations, and communicate evidence and explanations to others.

Science and Technology

Students become interested in technology as they design projects, use tools well, measure things carefully, make reasonable estimations, calculate accurately, and communicate clearly. They should begin to enjoy opportunities to clarify a problem, generate criteria for an acceptable solution, suggest possible solutions, try one out, and then make adjustments or start over with a new proposed solution. It is important for students to find out that there is more than one way to design a product or solve a problem. They also learn that some designs and solutions are better than others. To accomplish this, several groups of students can be asked to design and solve the same problem and then discuss the advantages and disadvantages of each solution with other students. Students see that solving one problem may lead to other problems. They are introduced to the balance between constraints and social impact.

Personal and Social Perspectives

A variety of experiences give students an initial understanding of various science-related personal and societal challenges. The *National Science Education Standards* (page 138) state "Central ideas related to health, populations, resources, and environments provide the foundations for students' eventual understandings and actions as citizens." Students learn that resources are the things that we get from the living and nonliving environment to meet human needs and wants. For example, they also learn that natural resources are limited and should be respected and used wisely. When students investigate making soil through composting, they learn that resources can be extended through recycling and wise use.

Science – Grade 3

The focus for third grade students is on identifying systems and patterns in systems. Systems are the units of investigations. A system is an interrelated group of objects or components that form a functioning unit. Students learn to identify portions of a system to facilitate investigation. Systems have boundaries, components, resources, flow and feedback. Guide student learning to continue to emphasize the unifying concepts previously introduced including evidence, explanation, measurement, order, organization, and change as well as the introduction at grade three of systems. The strands provide a context for teaching the content goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives

COMPETENCY GOAL 1: The learner will conduct investigations and build an understanding of plant growth and adaptations.

Objectives:

1.01 Observe and measure how the quantities and qualities of nutrients, light, and water in the environment affect plant growth.

1.02 Observe and describe how environmental conditions determine how well plants survive and grow in a particular environment.

1.03 Investigate and describe how plants pass through distinct stages in their life cycle including.
- Growth.
- Survival.
- Reproduction.

1.04 Explain why the number of seeds a plant produces depends on variables such as light, water, nutrients, and pollination.

1.05 Observe and discuss how bees pollinate flowers.

1.06 Observe, describe and record properties of germinating seeds.

COMPETENCY GOAL 2: The learner will conduct investigations to build an understanding of soil properties.

Objectives:

2.01 Observe and describe the properties of soil:
- Color.
- Texture.
- Capacity to hold water.

2.02 Investigate and observe that different soils absorb water at different rates.

2.03 Determine the ability of soil to support the growth of many plants, including those important to our food supply.

2.04 Identify the basic components of soil:
- Sand.
- Clay.
- Humus.

2.05 Determine how composting can be used to recycle discarded plant and animal material.

2.06 Determine the relationship between heat and decaying plant matter in a compost pile.

COMPETENCY GOAL 3: The learner will make observations and use appropriate technology to build an understanding of the earth/moon/sun system.

Objectives:

3.01 Observe that light travels in a straight line until it strikes an object and is reflected and/or absorbed.

3.02 Observe that objects in the sky have patterns of movement including:
- Sun.
- Moon.
- Stars.

3.03 Using shadows, follow and record the apparent movement of the sun in the sky during the day.

3.04 Use appropriate tools to make observations of the moon.

3.05 Observe and record the change in the apparent shape of the moon from day to day over several months and describe the pattern of changes.

3.06 Observe that patterns of stars in the sky stay the same, although they appear to move across the sky nightly.

COMPETENCY GOAL 4: The learner will conduct investigations and use appropriate technology to build an understanding of the form and function of the skeletal and muscle systems of the human body.

Objectives:

4.01 Identify the skeleton as a system of the human body.

4.02 Describe several functions of bones:
- Support.
- Protection.
- Locomotion.

4.03 Describe the functions of different types of joints:
- Hinge.
- Ball and socket.
- Gliding.

4.04 Describe how different kinds of joints allow movement and compare this to the movement of mechanical devices.

4.05 Observe and describe how muscles cause the body to move.

GRADE FOUR

Goal

The focus for the fourth grade student is on analyzing systems and learning how they work. Thinking about and analyzing systems helps students understand the relationships of mass, energy, objects, and organization. They learn that systems consist of combinations of organisms, machines, objects, ideas, and numbers. Systems have boundaries, components, resources flow and feedback. The following explanations characterize the strands at the fourth grade level.

Nature of Science

The Nature of Science Strand helps students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Science teaches that nature and natural laws are the same everywhere, and that nature is understandable and predictable. Students develop an understanding of the organization of systems, which in turn leads to understanding of basic laws of nature, scientific theories, and models that help explain the world. Students read, investigate, and learn that science is a human endeavor. Students begin to realize that doing science involves more than being a "scientist," and that science is used in many occupations including medicine, engineering, agriculture, business, and many others.

Science as Inquiry

Fourth grade students can master some skills of a good inquirer. Students make measurements using tools, rulers, thermometers, containers, and balances. They learn that the most useful skills are the ability to make careful measurements, to record observations and measurements, to make predictions based on observations, and to communicate results using charts and simple graphs as well as by writing and speaking. They discover that the best explanations of processes and events are based on evidence from systematic investigations. By grade four, students learn that similarities and differences between the properties of objects and materials can be understood and described in specific context, such as a set of rocks or a group of living materials. Through experiments with electricity and magnetism, students begin to understand that phenomena can be observed, measured and manipulated by changing specific variables. Students develop their abilities to communicate, infer, analyze, and critique their own work and that of other students. The results of their work may be spoken, drawn, written, or presented in multimedia.

Science and Technology

Students become interested in technology as they design projects, use tools well, measure things carefully, make reasonable predictions, calculate accurately, and communicate clearly. Students become confident in designing and analyzing projects, and the more experience they have with design, the less direct guidance they need. They begin to enjoy opportunities to clarify a problem, generate criteria for an acceptable solution, suggest possible solutions, try one out, and then make adjustments or start over with another proposed solution. It is important for students to find out that there is more than one way to design a product or solve a problem. To accomplish this goal, several groups of students can be asked to design and solve the same problem and then discuss the advantages and disadvantages of each solution. Students discover that solving some problems may lead to others, and they become able to use simple constraint in problem solving. Students learn to analyze and evaluate their own results and solutions, as well as those of other students, by considering how well a product or design met a specific challenge need or problem.

Personal and Social Perspectives

Students investigate the progression of uses of tools over time. They understand that people continue to invent new ways of solving problems and getting things done. As they research inventions and technological advances, students begin to understand how new ideas and inventions affect human life. They analyze advantages and disadvantages of new ideas and inventions and learn to consider the costs and benefits of various solutions.

Science – Grade 4

The focus for fourth grade students is on analyzing systems and learning how systems work. Thinking about and analyzing systems help students understand the relationships of mass, energy, objects, and organisms. Students learn that systems may be made up of subsystems and that systems have structure and function, feedback, equilibrium, and that there are both open and closed systems. Guide student learning to continue to emphasize the unifying concepts previously introduced (including evidence, explanation, measurement, order, organization and change, and systems) as well as the introduction at grade four of form and function. The strands provide a context for teaching the content throughout all goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives

COMPETENCY GOAL 1: The learner will make observations and conduct investigations to build an understanding of animal behavior and adaptation.

Objectives

1.01 Observe and describe how all living and nonliving things affect the life of a particular animal including:
- Other animals.
- Plants.
- Weather.
- Climate.

1.02 Observe and record how animals of the same kind differ in some of their characteristics and discuss possible advantages and disadvantages of this variation.

1.03 Observe and discuss how behaviors and body structures help animals survive in a particular habitat.

1.04 Explain and discuss how humans and other animals can adapt their behavior to live in changing habitats.

1.05 Recognize that humans can understand themselves better by learning about other animals.

COMPETENCY GOAL 2: The learner will conduct investigations and use appropriate technology to build an understanding of the composition and uses of rocks and minerals.

Objectives

2.01 Describe and evaluate the properties of several minerals.

2.02 Recognize that minerals have a definite chemical composition and structure, resulting in specific physical properties including:

- Hardness.
- Streak color.
- Luster.
- Magnetism.

2.03 Explain how rocks are composed of minerals.
2.04 Show that different rocks have different properties.
2.05 Discuss and communicate the uses of rocks and minerals.
2.06 Classify rocks and rock-forming minerals using student-made rules.
2.07 Identify and discuss different rocks and minerals in North Carolina including their role in geologic formations and distinguishing geologic regions.

COMPETENCY GOAL 3: The learner will make observations and conduct investigations to build an understanding of magnetism and electricity.

Objectives

3.01 Observe and investigate the pull of magnets on all materials made of iron and the pushes or pulls on other magnets.
3.02 Describe and demonstrate how magnetism can be used to generate electricity.
3.03 Design and test an electric circuit as a closed pathway including an energy source, energy conductor, and an energy receiver.
3.04 Explain how magnetism is related to electricity.
3.05 Describe and explain the parts of a light bulb.
3.06 Describe and identify materials that are conductors and non-conductors of electricity.
3.07 Observe and investigate that parallel and series circuits have different characteristics.
3.08 Observe and investigate the ability of electric circuits to produce light, heat, sound, and magnetic effects.
3.09 Recognize lightning as an electrical discharge and show proper safety behavior when lightning occurs.

COMPETENCY GOAL 4: The learner will conduct investigations and use appropriate technology to build an understanding of how food provides energy and materials for growth and repair of the body.

Objective

4.01 Explain why organisms require energy to live and grow.
4.02 Show how calories can be used to compare the chemical energy of different foods.
4.03. Discuss how foods provide both energy and nutrients for living organisms.
4.04 Identify starches and sugars as carbohydrates.
4.05 Determine that foods are made up of a variety of components:

GRADE FIVE

Goal

Fifth grade students focus on using evidence, models, and reasoning to form scientific explanations. Evidence consists of observations and data on which scientific explanations are based. Using evidence to understand interactions allows students to predict changes in natural and human-designed systems. Models are tentative schemes or structures constructed to represent real objects or processes. Models help students understand how things work. Explanations incorporate prior knowledge and new evidence from observations, experiments, or models into consistent, logical statements. As students come to understand science concepts and processes, their explanations should become more accurate and logical. Activities and other experiences for fifth grade students continue to emphasize the unifying concepts previously learned as well as the introduction of models at grade five. The following explanations characterize the strands at this grade level.

Nature of Science

The Nature of Science Strand helps students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Science investigations provide the background for developing and appreciating the nature of science. Science is a human endeavor and therefore relies on human qualities, including reasoning, insight, energy, skill and creativity. Students learn that science is involved in many different kinds of work and engages men and women of all ages and backgrounds.

Science as Inquiry

Students must actively participate in science investigations, and use the cognitive and manipulative skills necessary for formation of scientific explanations. They examine the validity of an explanation based on evidence rather than speculation. Through experiments and investigations students conduct, shape, and modify their knowledge of science concepts and processes. Students explore ecosystems in local environments, focusing on the interactions between living and nonliving things. They look at food webs within ecosystems and describe the relationships among producers, consumers, and decomposers while examining the energy flow from one organism to another in a food web. Students at this level should be able to formulate questions, design and carry out investigations, interpret and use data to generate explanations, and critique explanations and procedures. Students will construct understanding of the Earth's landforms and how those landforms change with time because of interactions among soil, rocks, water, and wind. Such investigations should lead students to conduct their own further investigations.

Science and Technology

Students should become interested in technology as they design projects, use tools well, measure things carefully, make reasonable predictions, calculate accurately, and communicate clearly. Students explore weather systems by observing, measuring, and recording local conditions. They use tools such as thermometers, rain gauges, and barometers to collect data and to identify weather patterns. Students gain confidence in designing and analyzing their products and solutions. The more experience students have with design, the less direct guidance they need. Students learn basic physical concepts about energy and forces affecting the motion of objects and the effects of design on the movements of a machine. They learn from opportunities to identify and clarify a problem, generate criteria for an acceptable solution, suggest possible solutions, try one out, and then make adjustments or start over with another proposed solution. They become competent designing, analyzing, and explaining their products and solutions. Does it work? How can I make it work better? Would it have worked better if I had used different materials? It is important for students to find out that there is more than one way to design a product or solve a problem. To accomplish this, several groups of students may be asked to design and solve the same problem and then discuss the advantages and disadvantages of each solution. Students see that solving some problems may lead to other problems, and gain the ability to overcome simple obstacles in problem solving. Students learn to analyze and evaluate their own results or solutions to problems, as well as those of other students, by considering how a product or design met the challenge to solve a problem.

Personal and Social Perspectives

Students investigate the progression of tool use and development of tools and machines over time. They understand that humans continue inventing new ways of solving problems and getting things done. As they study inventions and technological advances, they begin to understand how new ideas and inventions affect people. They analyze the advantages and disadvantages of new ideas and inventions. As students study ecosystems they will become acquainted with what happens when changes occur when the environment becomes overpopulated and the use of resources increases. Through investigation of landforms students observe earth's external processes that cause natural changes and present challenges, including landslides, floods, and storms.

Science – Grade 5

Fifth grade students focus on evidence, models, and scientific explanations. Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows students to predict changes in natural and designed systems. Models are tentative schemes or structures that represent real objects. Models help students understand how things work. Explanations incorporate prior scientific knowledge and new evidence from observations, experiments, or models into consistent, logical statements. As students understand more science concepts and processes, their explanations should become more accurate and logical. Guide student learning to continue to emphasize the unifying concepts previously introduced as well as the introduction at grade five of models. The strands provide a context for teaching the content throughout all goals.

Strands: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives.

COMPETENCY GOAL 1: The learner will conduct investigations to build an understanding of the interdependence of plants and animals.

Objectives

1.01 Describe and compare several common ecosystems (communities of organisms and their interaction with the environment).

1.02 Identify and analyze the functions of organisms within the population of the ecosystem:
- Producers.
- Consumers.
- Decomposers.

1.03 Explain why an ecosystem can support a variety of organisms.

1.04 Discuss and determine the role of light, temperature, and soil composition in an ecosystem's capacity to support life.

1.05 Determine the interaction of organisms within an ecosystem.

1.05 Explain and evaluate some ways that humans affect ecosystems.
- Habitat reduction due to development.
- Pollutants.
- Increased nutrients.

1.05 Determine how materials are recycled in nature.

COMPETENCY GOAL 2: The learner will make observations and conduct investigations to build an understanding of landforms.

Objectives

2.01 Identify and analyze forces that cause change in landforms over time including.
- Water and Ice.
- Wind.
- Gravity.

2.02 Investigate and discuss the role of the water cycle and how movement of water over and through the landscape helps shape land forms.

2.03 Discuss and consider the wearing away and movement of rock and soil in erosion and its importance in forming:
- Canyons.
- Valleys.
- Meanders.
- Tributaries.

2.04 Describe the deposition of eroded material and its importance in establishing landforms including:
- Deltas.
- Flood Plains.

2.05 Discuss how the flow of water and the slope of the land affect erosion.

2.06 Identify and use models, maps, and aerial photographs as ways of representing landforms.

2.07 Discuss and analyze how humans influence erosion and deposition in local communities, including school grounds, as a result of:
- Clearing land.
- Planting vegetation.
- Building dams.

COMPETENCY GOAL 3: The learner will conduct investigations and use appropriate technology to build an understanding of weather and climate.

Objectives

3.01 Investigate the water cycle including the processes of:
- Evaporation.
- Condensation.
- Precipitation.
- Run-off.

3.02 Discuss and determine how the following are affected by predictable patterns of weather:
- Temperature.
- Wind direction and speed.
- Precipitation.

- Cloud cover.
- Air pressure.

3.03 Describe and analyze the formation of various types of clouds and discuss their relation to weather systems.

3.04 Explain how global atmospheric movement patterns affect local weather.

3.05 Compile and use weather data to establish a climate record and reveal any trends.

3.06 Discuss and determine the influence of geography on weather and climate:
- Mountains
- Sea breezes
- Water bodies.

COMPETENCY GOAL 4: The learner will conduct investigations and use appropriate technologies to build an understanding of forces and motion in technological designs.

Objectives

4.01 Determine the motion of an object by following and measuring its position over time.

4.02 Evaluate how pushing or pulling forces can change the position and motion of an object.

4.03 Explain how energy is needed to make machines move.
- Moving air.
- Gravity.

4.04 Determine that an unbalanced force is needed to move an object or change its direction.

4.05 Determine factors that affect motion including:
- Force
- Friction.
- Inertia.
- Momentum

4.06 Build and use a model to solve a mechanical design problem.
- Devise a test for the model.
- Evaluate the results of test.

4.07 Determine how people use simple machines to solve problems.

Middle Grades 6 – 8

The middle school science component of the *SCS* focuses on the Unifying Concepts of Science as identified by the *National Science Education Standards*. The unifying concepts and the Strands should be integrated with science content goals and objectives for middle school.

The Unifying Concepts of Science consist of:

- Systems, Order, and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

The **Strands** include the following goals:

Nature of Science

As a result of activities in grades 6-8, all students should develop an understanding of:

- Science as a human endeavor.
- Nature of scientific knowledge.
- Historical perspectives.

Science as Inquiry

As a result of activities in grades 6-8, all students should develop an understanding of:

- Ability to do scientific inquiry.
- Understanding about scientific inquiry.
- Ability to perform safe and appropriate manipulation of materials, scientific equipment, and technology.
- Mastery of integrated process skills.
  - -acquiring, processing, and interpreting data
  - -identifying variables and their relationships
  - -designing investigations
  - -experimenting
  - -analyzing investigations
  - -constructing hypotheses
  - -formulating models

Science and Technology

As a result of activities in grades 6-8, all students should develop an understanding of:

- What technologies are.
- Ability to perform technological design.
- Understanding science and technology.

Science in Personal and Social Perspectives

As a result of activities in grades 6-8, all students should develop an understanding of:

- Personal and community health.
- Population dynamics.
- Environmental quality.
- Natural and human-induced hazards.
- Science and technology in local, national, and global challenges.
- Careers in science and technology.

GRADE SIX

Goal

Sixth grade science builds on the concepts and skills acquired in kindergarten through fifth grade. Instructional design should provide opportunities for understanding: the unifying concepts of science, the strands, conceptual goals and objectives. Connections to mathematics, technology, social science, and communication skills should be considered for instructional design. To assist teachers with instruction, materials explaining the Unifying Concepts, Strands, Goals, and Objectives with specific recommendations for classroom, laboratory, and/or field experiences are available through the Department of Public Instruction.

It is important that the nature of the adolescent be at the core of all curricula. Middle school students are undergoing extensive psychological, physiological, and social changes, which make them curious, energetic, and egocentric. Middle school science provides opportunities to channel the interests and concerns of adolescents, provided it maximizes their exposure to high interest topics. Middle school learners need to see a direct relationship between science education and daily life. Investigations designed to help students learn about themselves and their world motivate them.

Designing technological solutions and pondering benefits and risks should be an integral part of the middle school science experience. As students take the initiative to learn science and technology, they will learn about themselves, their community and potential career paths. The confidence to pursue such personal goals can be instilled through successful science experience.

Nature of Science

Science is a human endeavor that relies on reasoning, insight, skill, and creativity. A parallel reliance on scientific habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas is crucial to the advancement of science and technology. Science would be a stagnant body of knowledge, were it not for humans continually seeking to understand and explain the natural world and their role in it. Capitalizing on the continuous public review of science and technology, middle

school students should understand that the very nature of science is for some ideas to be constant yet tentative, probabilistic, historic, and replicable.

Many of science's universal laws are very old ideas that still apply today. In addition, using history to trace the technology evolution that led us from an agricultural to an industrial to an information and communication-based society exemplifies the nature of science. Public acceptance of modified or new ideas exemplifies the struggle of scientists who attempt to advance scientific knowledge or make breakthroughs. The learner should appreciate the efforts of past scientists that have given rise to modern science and technology.

A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System.*

Science as Inquiry

Traditional laboratory experiences provide opportunities to demonstrate how science is constant, historic, probabilistic, and replicable. Although there are no fixed steps that all scientists follow, scientific investigations usually involve collections of relevant evidence, the use of logical reasoning, the application of imagination to devise hypotheses, and explanations to make sense of collected evidence. Student engagement in scientific investigation provides background for understanding the nature of scientific inquiry. In addition, the science process skills necessary for inquiry are acquired through active experience. The process skills support development of reasoning and problem-solving ability and are the core of scientific methodologies. Students should:

- Structure questions that can be answered through scientific investigations.
- Clarify ideas that guide and influence the inquiry.

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- Structure questions that can be answered through scientific investigations.
- Clarify ideas that guide and influence the inquiry.

- Design and conduct scientific investigations to test ideas.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Control and manipulate variables.
- Use appropriate resources and tools to gather, analyze, interpret, and communicate data.
- Use mathematics to gather, organize, and present data.

Students should:

- Make inferences from data .
- Use evidence to offer descriptions, predictions and models.
- Think critically and logically to bridge the relationships between evidence and explanations.
- Recognize and evaluate alternative explanations.
- Review experimental procedures.
- Communicate scientific procedures, results, and explanations.
- Formulate questions leading to further investigations.

Science and Technology

Science is the foundation of technology and new technology is necessary for the advancement of science. This reciprocity of science and technology should be emphasized with middle school learners. Current media topics, emerging technologies, and research issues provide a real-world context for understanding and applying targeted grade-level skills and concepts.

A single problem often has both scientific and technological aspects. For example, investigating the salinity of the water in North Carolina's sounds is the pursuit of science, while creating a way to make this salt water drinkable is the pursuit of technology. In other words, while science tries to understand the natural world, technology tries to solve practical problems. Technology expands our capacity to understand the world and to control the natural and human-made environment. Technology asks questions like "How does this work?" and "How can it be improved?"

The word "technology" has many definitions. It may, for example, mean a particular way of doing things, and or it may denote a specific object. Stephen Kiln, Professor of Mechanical Engineering at Stanford University has four definitions of technology (Kiln, 1985):

- artifact or hardware. (e.g., an aspirin, chair, computer, or video tape)
- methodology or technique. (e.g., painting, using a microscope or calculator)
- system of production. (e.g., the automobile assembly line, a process for manufacturing a product or an entire industry)
- social-technical system. (an airplane, for example, suggests a plethora of interrelated devices, human resources, and artifacts such as airports, passengers and pilots, fuel, regulations and ticketing).

Technology provides tools for understanding natural phenomena and often sparks scientific advances. It has always played a role in the growth of scientific knowledge. The techniques for shaping, producing or manufacturing tools, for example, are seen as the primary evidence of the beginning of human culture. Applying scientific knowledge of materials and processes to the benefit of people has been a determining factor in shaping our culture.

While understanding the connection of science and technology is critical, the ability to distinguish between the work of engineers and scientists also should be explored. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technology design skills are parallel to inquiry skills in science.
It is critical that students understand that technology enables us to design adaptations to the natural world but not without both positive and negative consequences. The limits on science's ability to answer all questions, and on technology's ability to design solutions for all adaptive problems, also must be stressed. Design requires that technological solutions adhere to the universal laws of nature. Constraints such as gravity or the properties of the materials to be used are critical to the success of a technological solution. Other constraints, including cost, time, politics, society, ethics, and aesthetics, also define parameters and limit choices. Students should analyze

benefits and costs of technological solutions. Fundamental abilities of technological design include the ability to:

- Identify problems appropriate for technological design.
- Develop criteria for evaluating the product or solution.
- Identify constraints that must be taken into consideration
- Design a product or solution.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Implement a proposed design.
- Evaluate completed design or product.
- Analyze the risks and benefits of the solution.
- Communicate the process of technological design.
- Review the process of technological design.

Science in Personal and Social Perspectives

The ultimate goal for a scientifically literate person is the ability to use appropriate scientific principles and processes in making personal decisions. Therefore, making personal and societal connections to scientific challenges is imperative for middle school learners. Concepts, skills and theories for middle school science afford opportunities to develop scientific understanding for many aspects of personal and societal health. Opportunities that nurture students' abilities to think creatively and scientifically abound, as students connect science to personal decision making. Personal and societal connections can be made as sixth grade students conduct in-depth investigations which:

- analyze the role of humans in the natural world using issues that concern the lithosphere.
- interpret the interconnectedness of all organisms in an ecosystem and the effect of disturbing parts of a system.
- evaluate the benefits and knowledge gained from space exploration.
- investigate the importance of soil quality.

Science – Grade 6

Learners will study natural and technological systems. All goals should focus on the unifying concepts of science defined by the *National Science Education Standards*: Systems, Order, and Organization; Evidence, Models, and Explanation; Constancy, Change, and Measurement; Evolution and Equilibrium; and Form and Function. The skills of inquiry and technological design are targeted for mastery. The concepts for which in-depth studies should be designed at sixth grade level include: Scientific Inquiry, Technological Design, Lithosphere, Cycling of Matter, Solar System, Energy Transfer/Transformation, and Population Dynamics.

Strands: The Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives Strands provide the context for content goals.

COMPETENCY GOAL 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.

Objectives

1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.

1.02 Develop appropriate experimental procedures for:
- Given questions.
- Student generated questions.

1.03 Apply safety procedures in the laboratory and in field studies:
- Recognize potential hazards.
- Manipulate materials and equipment.
- Conduct appropriate procedures.

1.04 Analyze variables in scientific investigations:
- Identify dependent and independent.
- Use of a control.
- Manipulate.
- Describe relationships between.
- Define operationally.

1.05 Analyze evidence to:
- Explain observations.
- Make inferences and predictions.
- Develop the relationship between evidence and explanation.

1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
- Measurement.
- Analysis of data.
- Graphing.
- Prediction models.

1.07 Prepare models and/or computer simulations to:
- Test hypotheses.
- Evaluate how data fit.

1.08 Use oral and written language to:
- Communicate findings.
- Defend conclusions of scientific investigations.

1.09 Use technologies and information systems to:
- Research.
- Gather and analyze data.
- Visualize data.
- Disseminate findings to others.

1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing:
- Scientific text.
- Articles.
- Events in the popular press.

COMPETENCY GOAL 2: The learner will demonstrate an understanding of technological design.

Objectives

2.01 Explore evidence that "technology" has many definitions.
- Artifact or hardware.
- Methodology or technique.
- System of production.
- Social-technical system.

2.02 Use information systems to:
- Identify scientific needs, human needs, or problems that are subject to technological solution.
- Locate resources to obtain and test ideas.

2.03 Evaluate technological designs for:
- Application of scientific principles.
- Risks and benefits.
- Constraints of design.
- Consistent testing protocols.

2.04 Apply tenets of technological design to make informed consumer decisions about:
- Products.
- Processes.
- Systems.

COMPETENCY GOAL 3: The learner will build an understanding of the geological cycles, forces, processes, and agents which shape the lithosphere.

Objectives

3.01 Evaluate the forces that shape the lithosphere including:
- Crustal plate movement.
- Folding and faulting.
- Deposition.
- Volcanic Activity.
- Earthquakes.

3.02 Examine earthquake and volcano patterns.

3.03 Explain the model for the interior of the earth.

3.04 Describe the processes which form and the uses of earth materials.
- Rock cycle.
- Minerals.
- Characteristics of rocks.
- Economic use of rocks and minerals.
- Value of gems and precious metals.
- Common gems, minerals, precious metals and rocks found in N.C.

3.05 Analyze soil properties that can be observed and measured to predict soil quality including:
- Color.
- Horizon profile.
- Infiltration.
- Soil temperature.
- Structure.
- Consistency.
- Texture.
- Particle size.
- pH.
- Fertility.
- Soil moisture.

3.06 Evaluate ways in which human activities have affected Earth's pedosphere and the measures taken to control the impact:
- Vegetative cover.
- Agriculture.
- Land use.
- Nutrient balance.
- Soil as a vector.

3.07 Assess the use of technology and information systems in monitoring lithospheric phenomenon.

3.08 Conclude that the good health of environments and organisms requires:
- Monitoring of the pedosphere.
- Taking steps to maintain soil quality.
- Stewardship.

COMPETENCY GOAL 4: The learner will investigate the cycling of matter.

Objectives

4.01 Describe the flow of energy and matter in natural systems:
- Energy flows through ecosystems in one direction, from the sun through producers to consumers to decomposers.
- Matter is transferred from one organism to another and between organisms and their environments.
- Water, nitrogen, carbon dioxide, and oxygen are substances cycled between the living and non-living environments.

4.02 Evaluate the significant role of decomposers.

4.03 Examine evidence that green plants make food.
- Photosynthesis is a process carried on by green plants and other organisms containing chlorophyll.
- During photosynthesis, light energy is converted into stored energy which the plant, in turn, uses to carry out its life processes.

4.04 Evaluate the significance of photosynthesis to other organisms:
- The major source of atmospheric oxygen is photosynthesis.
- Carbon dioxide is removed from the atmosphere and oxygen is released during photosynthesis.
- Green plants are the producers of food that is used directly or indirectly by consumers.

4.05 Evaluate designed systems for ability to enable growth of certain plants and animals.

COMPETENCY GOAL 5: The learner will build understanding of the Solar System.

Objectives

5.01 Analyze the components and cycles of the solar system including:
- Sun.
- Planets and moons.
- Asteroids and meteors.
- Comets.
- Phases.
- Seasons.
- Day/year.
- Eclipses.

5.02 Compare and contrast the Earth to other planets in terms of:
- Size.
- Composition.
- Relative distance from the sun.
- Ability to support life.

5.03 Relate the influence of the sun and the moon's orbit to the gravitational effects produced on Earth.
- Solar storms.
- Tides.

5.04 Describe space explorations and the understandings gained from them including:
- N.A.S.A.
- Technologies used to explore space.
- Historic timeline.
- Apollo mission to the moon.
- Space Shuttle.
- International Space Station.
- Future goals.

5.05 Describe the setting of the solar system in the universe including:
- Galaxy.
- Size.
- The uniqueness of Earth.

5.06 Analyze the spin-off benefits generated by space exploration technology including:
- Medical.
- Materials.
- Transportation.
- Processes.
- Future research.

COMPETENCY GOAL 6: The learner will conduct investigations and examine models and devices to build an understanding of the characteristics of energy transfer and/or transformation.

Objectives

6.01 Determine how convection and radiation transfer energy.

6.02 Analyze heat flow through materials or across space from warm objects to cooler objects until both objects are at equilibrium.

6.03 Analyze sound as an example that vibrating materials generate waves that transfer energy.
- Frequency.
- Amplitude.
- Loudness.
- How sound travels through different material.
- Form and function of the human ear.

6.04 Evaluate data for qualitative and quantitative relationships associated with energy transfer and/or transformation.

6.05 Analyze the physical interactions of light and matter:
- Absorption.
- Scattering.
- Color perception.
- Form and function of the human eye.

6.06 Analyze response to heat to determine the suitability of materials for use in technological design:
- Conduction.
- Expansion.
- Contraction.

6.07 Analyze the Law of Conservation of Energy:
- Conclude that energy cannot be created or destroyed, but only changed from one form into another.
- Conclude that the amount of energy stays the same, although within the process some energy is always converted to heat.
- Some systems transform energy with less loss of heat than others.

COMPETENCY GOAL 7: The learner will conduct investigations and use technologies and information systems to build an understanding of population dynamics.

Objectives

7.01 Describe ways in which organisms interact with each other and with non-living parts of the environment:
- Coexistence/Cooperation/Competition.
- Symbiosis.
- Mutual dependence.

7.02 Investigate factors that determine the growth and survival of organisms including:
- Light.
- Temperature range.
- Mineral availability.
- Soil/rock type.
- Water.
- Energy.

7.03 Explain how changes in habitat may affect organisms.

7.04 Evaluate data related to human population growth, along with problems and solutions:
- Waste disposal.
- Food supplies.
- Resource availability.
- Transportation.
- Socio-economic patterns.

7.05 Examine evidence that overpopulation by any species impacts the environment.

7.06 Investigate processes which, operating over long periods of time, have resulted in the diversity of plant and animal life present today:
- Natural selection.
- Adaptation.

GRADE SEVEN

Goal

Seventh grade science builds on the concepts and skills acquired in kindergarten through sixth grade. Instructional design should provide opportunities for understanding: the unifying concepts of science, the strands, conceptual goals and objectives. Connections to mathematics, technology, social science, and communication skills should be considered for instructional design. To assist teachers with instruction, materials explaining Unifying Concepts, Strands, Goals and Objectives with specific recommendations for classroom, laboratory, and/or field experiences are available through the Department of Public Instruction.

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A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System.*

Science as Inquiry

Traditional laboratory experiences provide opportunities to demonstrate how science is constant, historic, probabilistic, and replicable. Although there are no fixed steps that all scientists follow, scientific investigations usually involve collections of relevant evidence, the use of logical reasoning, the application of imagination to devise hypotheses, and explanations to make sense of collected evidence. Student engagement in scientific investigation provides background for understanding the nature of scientific inquiry. In addition, the science process skills necessary for inquiry are acquired through active experience. The process skills support development of reasoning and problem-solving ability and are the core of scientific methodologies. Students should:

- Structure questions that can be answered through scientific investigations.
- Clarify ideas that guide and influence the inquiry.

- Design and conduct scientific investigations to test ideas.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Control and manipulate variables.
- Use appropriate resources and tools to gather, analyze, interpret, and communicate data.
- Use mathematics to gather, organize, and present data.

Students should:
- Make inferences from data .
- Use evidence to offer descriptions, predictions and models.
- Think critically and logically to bridge the relationships between evidence and explanations.
- Recognize and evaluate alternative explanations.
- Review experimental procedures.
- Communicate scientific procedures, results, and explanations.
- Formulate questions leading to further investigations.

Science and Technology

Science is the foundation of technology and new technology is necessary for the advancement of science. This reciprocity of science and technology should be emphasized with middle school learners. Current media topics, emerging technologies, and research issues provide a real-world context for understanding and applying targeted grade-level skills and concepts.

A single problem often has both scientific and technological aspects. For example, investigating the salinity of the water in North Carolina's sounds is the pursuit of science, while creating a way to make this salt water drinkable is the pursuit of technology. In other words, while science tries to understand the natural world, technology tries to solve practical problems. Technology expands our capacity to understand the world and to control the natural and human-made environment. Technology asks questions like "How does this work?" and "How can it be improved?"

The word "technology" has many definitions. It may, for example, mean a particular way of doing things, and or it may denote a specific object. Stephen Kiln, Professor of Mechanical Engineering at Stanford University has four definitions of technology (Kiln, 1985):

- artifact or hardware. (e.g., an aspirin, chair, computer, or video tape)
- methodology or technique. (e.g., painting, using a microscope or calculator)
- system of production. (e.g., the automobile assembly line, a process for manufacturing a product or an entire industry)
- social-technical system. (an airplane, for example, suggests a plethora of interrelated devices, human resources, and artifacts such as airports, passengers and pilots, fuel, regulations and ticketing).

Technology provides tools for understanding natural phenomena and often sparks scientific advances. It has always played a role in the growth of scientific knowledge. The techniques for shaping, producing or manufacturing tools, for example, are seen as the primary evidence of the beginning of human culture. Applying scientific knowledge of materials and processes to the benefit of people has been a determining factor in shaping our culture.

While understanding the connection of science and technology is critical, the ability to distinguish between the work of engineers and scientists also should be explored. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technology design skills are parallel to inquiry skills in science.
It is critical that students understand that technology enables us to design adaptations to the natural world but not without both positive and negative consequences. The limits on science's ability to answer all questions, and on technology's ability to design solutions for all adaptive problems, also must be stressed. Design requires that technological solutions adhere to the universal laws of nature. Constraints such as gravity or the properties of the materials to be used are critical to the success of a technological solution. Other constraints, including cost,

time, politics, society, ethics, and aesthetics, also define parameters and limit choices. Students should analyze benefits and costs of technological solutions. Fundamental abilities of technological design include the ability to:

- Identify problems appropriate for technological design.
- Develop criteria for evaluating the product or solution.
- Identify constraints that must be taken into consideration
- Design a product or solution.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Implement a proposed design.
- Evaluate completed design or product.
- Analyze the risks and benefits of the solution.
- Communicate the process of technological design.
- Review the process of technological design.

Science in Personal and Social Perspectives

The ultimate goal for a scientifically literate person is the ability to use appropriate scientific principles and processes in making personal decisions. Therefore, making personal and societal connections to scientific challenges is imperative for middle school learners. Concepts, skills and theories for middle school science afford opportunities to develop scientific understanding for many aspects of personal and societal health. Opportunities that nurture students' abilities to think creatively and scientifically abound, as students connect science to personal decision making. Personal and societal connections can be made as seventh grade students conduct in-depth investigations which:

- Analyze the role of humans in the natural world using issues that concern the atmosphere.
- Analyze the use of technology in predicting, monitoring, and recording atmospheric data.
- Explore human characteristics that are genetically determined.
- Evaluate the importance of air quality.
- Investigate examples of interacting forces in transportation, sports, and the human body.

Science – Grade 7

Learners will study natural and technological systems. All goals should focus on the unifying concepts of science defined by the *National Science Education Standards*: Systems, Order, and Organization; Evidence, Models, and Explanation; Constancy, Change, and Measurement; Evolution and Equilibrium; and Form and Function. The skills of inquiry and technological design are targeted for mastery. The concepts for which in-depth studies should be designed at seventh grade level include: Scientific Inquiry, Technological Design, Atmosphere, Human Body Systems, Genetics and Heredity, and Motion and Forces.

Strands: The Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives Strands provide the context for content goals.

COMPETENCY GOAL 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.

Objectives

1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.

1.02 Develop appropriate experimental procedures for:
- Given questions.
- Student generated questions.

1.03 Apply safety procedures in the laboratory and in field studies.
- Recognize potential hazards.
- Safely manipulate materials and equipment.
- Conduct appropriate procedures.

1.04 Analyze variables in scientific investigations:
- Identify dependent and independent.
- Use of a Control.
- Manipulate.
- Describe relationships between.
- Define operationally.

1.05 Analyze evidence to:
- Explain observations.
- Make inferences and predictions.
- Develop the relationship between evidence and explanation.

1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
- Measurement.
- Analysis of data.
- Graphing.
- Prediction models.

1.07 Prepare models and/or computer simulations to:
- Test hypotheses.
- Evaluate how data fit.

1.08 Use oral and written language to:
- Communicate findings.
- Defend conclusions of scientific investigations

1.09 Use technologies and information systems to:
- Research.
- Gather and analyze data.
- Visualize data.
- Disseminate findings to others.

1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing:
- Scientific text.
- Articles.
- Events in the popular press.

COMPETENCY GOAL 2: The learner will demonstrate an understanding of technological design.

Objectives

2.01 Explore evidence that "technology" has many definitions.
- Artifact or hardware.
- Methodology or technique.
- System of production.
- Social-technical system.

2.02 Use information systems to:
- Identify scientific needs, human needs, or problems that are subject to technological solution.
- Locate resources to obtain and test ideas.

2.03 Evaluate technological designs for:
- Application of scientific principles.
- Risks and benefits.
- Constraints of design.
- Consistent testing protocols.

2.04 Apply tenets of technological design to make informed consumer decisions about:
- Products.
- Processes.
- Systems.

COMPETENCY GOAL 3: The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of the atmosphere.

Objectives

3.01 Explain the composition, properties and structure of the atmosphere:
- Mixture of gases.
- Stratified layers.
- Each layer has distinct properties.
- As altitude increases, air pressure decreases.
- Equilibrium.

3.02 Describe properties that can be observed and measured to predict air quality:
- Particulate matter.
- Ozone.

3.03 Conclude that the good health of environments and organisms requires:
- The monitoring of air quality.
- Taking steps to maintain healthy air quality.
- Stewardship.

3.04 Evaluate how humans impact air quality including:
- Air quality standards.
- Point and non-point sources of air pollution in North Carolina.
- Financial and economic trade-offs.
- Local air quality issues.

3.05 Examine evidence that atmospheric properties can be studied to predict atmospheric conditions and weather hazards:
- Humidity.
- Temperature.
- Wind speed and direction.
- Air pressure.
- Precipitation.
- Tornados.
- Hurricanes.
- Floods.
- Storms.

3.06 Assess the use of technology in studying atmospheric phenomena and weather hazards:
- Satellites.
- Weather maps.
- Predicting.
- Recording.
- Communicating information about conditions.

COMPETENCY GOAL 4: The learner will conduct investigations, use models, simulations, and appropriate technologies and information systems to build an understanding of the complementary nature of the human body system.

Objectives

4.01 Analyze how human body systems interact to provide for the needs of the human organism:
- Musculoskeletal.
- Cardiovascular.
- Endocrine and Nervous.
- Digestive and Circulatory.
- Excretory.
- Reproductive.
- Respiratory.
- Immune.
- Nervous system.

4.02 Describe how systems within the human body are defined by the functions it performs.

4.03 Explain how the structure of an organ is adapted to perform specific functions within one or more systems.
- Liver.
- Heart.
- Lung.
- Brain
- Stomach.
- Kidney.

4.04 Evaluate how systems in the human body help regulate the internal environment.

4.05 Analyze how an imbalance in homeostasis may result from a disruption in any human system.

4.06 Describe growth and development of the human organism.

4.07 Explain the effects of environmental influences on human embryo development and human health including:
- Smoking.
- Alcohol.
- Drugs.
- Diet.

4.08 Explain how understanding human body systems can help make informed decisions regarding health.

Competency Goal 5: **The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of heredity and genetics.**

Objectives

5.01 Explain the significance of genes to inherited characteristics:
- Genes are the units of information.
- Parents transmit genes to their offspring.
- Some medical conditions and diseases are genetic.

5.02 Explain the significance of reproduction:
- Sorting and recombination of parents' genetic material.
- Potential variation among offspring.

5.03 Identify examples and patterns of human genetic traits:
- Dominant and recessive.
- Incomplete dominance.

5.04 Analyze the role of probability in the study of heredity:
- Role of each parent in transfer of genetic traits.
- Analysis of pedigrees.

5.05 Summarize the genetic transmittance of disease.

5.06 Evaluate evidence that human characteristics are a product of:
- Inheritance.
- Environmental factors, and
- Lifestyle choices.

Competency Goal 6: The learner will conduct investigations, use models, simulations, and appropriate technologies and information systems to build an understanding of motion and forces.

Objectives

6.01 Demonstrate ways that simple machines can change force.

6.02 Analyze simple machines for mechanical advantage and efficiency.

6.03 Evaluate motion in terms of Newton's Laws:
- The force of friction retards motion.
- For every action there is an equal and opposite reaction.
- The greater the force, the greater the change in motion.
- An object's motion is the result of the combined effect of all forces acting on the object:
- A moving object that is not subjected to a force will continue to move at a constant speed in a straight line
- An object at rest will remain at rest.

6.04 Analyze that an object's motion is always judged relative to some other object or point.

6.05 Describe and measure quantities that characterize moving objects and their interactions within a system:
- Time.
- Distance.
- Mass.
- Force.
- Velocity.
- Center of mass.
- Acceleration.

6.06 Investigate and analyze the real world interactions of balanced and unbalanced forces:
- Sports and recreation.
- Transportation.
- The human body.

GRADE EIGHT

Goal

Eighth grade science builds on the concepts and skills acquired in kindergarten through seventh grade. Instructional design should provide opportunities for understanding: the unifying concepts of science, the strands, conceptual goals and objectives. Connections to mathematics, technology, social science, and communication skills should be considered for instructional design. To assist teachers with instruction, materials explaining Unifying Concepts, Strands, Goals and Objectives with specific recommendations for classroom, laboratory, and/or field experiences are available through the Department of Public Instruction.

It is important that the nature of the adolescent be at the core of all curricula. Middle school students are undergoing extensive psychological, physiological, and social changes, which make them curious, energetic, and egocentric. Middle school science provides opportunities to channel the interests and concerns of adolescents, provided it maximizes their exposure to high interest topics. Middle school learners need to see a direct relationship between science education and daily life. Investigations designed to help students learn about themselves and their world motivate them.

Designing technological solutions and pondering benefits and risks should be an integral part of the middle school science experience. As students take the initiative to learn science and technology, they will learn about themselves, their community and potential career paths. The confidence to pursue such personal goals can be instilled through successful science experience.

Nature of Science

Science is a human endeavor that relies on reasoning, insight, skill, and creativity. A parallel reliance on scientific habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas is crucial to the advancement of science and technology. Science would be a stagnant body of knowledge, were it not for humans continually seeking to understand and explain the natural world and their role in it. Capitalizing on the continuous public review of science and technology, middle

school students should understand that the very nature of science is for some ideas to be constant yet tentative, probabilistic, historic, and replicable.

Many of science's universal laws are very old ideas that still apply today. In addition, using history to trace the technology evolution that led us from an agricultural to an industrial to an information and communication-based society exemplifies the nature of science. Public acceptance of modified or new ideas exemplifies the struggle of scientists who attempt to advance scientific knowledge or make breakthroughs. The learner should appreciate the efforts of past scientists that have given rise to modern science and technology.

A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System.*

Science as Inquiry

Traditional laboratory experiences provide opportunities to demonstrate how science is constant, historic, probabilistic, and replicable. Although there are no fixed steps that all scientists follow, scientific investigations usually involve collections of relevant evidence, the use of logical reasoning, the application of imagination to devise hypotheses, and explanations to make sense of collected evidence. Student engagement in scientific investigation provides background for understanding the nature of scientific inquiry. In addition, the science process skills necessary for inquiry are acquired through active experience. The process skills support development of reasoning and problem-solving ability and are the core of scientific methodologies. Students should:

- Structure questions that can be answered through scientific investigations.
- Clarify ideas that guide and influence the inquiry.

- Design and conduct scientific investigations to test ideas.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Control and manipulate variables.
- Use appropriate resources and tools to gather, analyze, interpret, and communicate data.
- Use mathematics to gather, organize, and present data.
- Make inferences from data.
- Use evidence to offer descriptions, predictions and models.
- Think critically and logically to bridge the relationships between evidence and explanations.
- Recognize and evaluate alternative explanations.
- Review experimental procedures.
- Communicate scientific procedures, results, and explanations.
- Formulate questions leading to further investigations.

Science and Technology

Science is the foundation of technology and new technology is necessary for the advancement of science. This reciprocity of science and technology should be emphasized with middle school learners. Current media topics, emerging technologies, and research issues provide a real-world context for understanding and applying targeted grade-level skills and concepts.

A single problem often has both scientific and technological aspects. For example, investigating the salinity of the water in North Carolina's sounds is the pursuit of science, while creating a way to make this salt water drinkable is the pursuit of technology. In other words, while science tries to understand the natural world, technology tries to solve practical problems. Technology expands our capacity to understand the world and to control the natural and human-made environment. Technology asks questions like "How does this work?" and "How can it be improved?"

The word “technology” has many definitions. It may, for example, mean a particular way of doing things, or it may denote a specific object. Stephen Kiln, Professor of Mechanical Engineering at Stanford University has four definitions of technology (Kiln, 1985):

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- social-technical system. (an airplane, for example, suggests a plethora of interrelated devices, human resources, and artifacts such as airports, passengers and pilots, fuel, regulations and ticketing).

Technology provides tools for understanding natural phenomena and often sparks scientific advances. It has always played a role in the growth of scientific knowledge. The techniques for shaping, producing or manufacturing tools, for example, are seen as the primary evidence of the beginning of human culture. Applying scientific knowledge of materials and processes to the benefit of people has been a determining factor in shaping our culture.

While understanding the connection of science and technology is critical, the ability to distinguish between the work of engineers and scientists also should be explored. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technology design skills are parallel to inquiry skills in science.
It is critical that students understand that technology enables us to design adaptations to the natural world but not without both positive and negative consequences. The limits on science’s ability to answer all questions, and on technology’s ability to design solutions for all adaptive problems, also must be stressed. Design requires that technological solutions adhere to the universal laws of nature. Constraints such as gravity or the properties of the materials to be used are critical to the success of a technological solution. Other constraints, including cost, time, politics, society, ethics, and aesthetics, also define parameters and limit choices. Students should analyze

benefits and costs of technological solutions. Fundamental abilities of technological design include the ability to:

- Identify problems appropriate for technological design.
- Develop criteria for evaluating the product or solution.
- Identify constraints that must be taken into consideration.
- Design a product or solution.
- Apply safe and appropriate abilities to manipulate materials, equipment, and technologies.
- Implement a proposed design.
- Evaluate completed design or product.
- Analyze the risks and benefits of the solution.
- Communicate the process of technological design.
- Review the process of technological design.

Science in Personal and Social Perspectives

The ultimate goal for a scientifically literate person is the ability to use appropriate scientific principles and processes in making personal decisions. Therefore, making personal and societal connections to scientific challenges is imperative for middle school learners. Concepts, skills and theories for middle school science afford opportunities to develop scientific understanding for many aspects of personal and societal health. Opportunities that nurture students' abilities to think creatively and scientifically abound, as students connect science to personal decision making. Personal and societal connections can be made as eighth grade students conduct in-depth investigations which:

- Evaluate the theories of biological, geological, and technological evolution.
- Analyze information from technologies utilized to monitor the earth from space.
- Evaluate the importance of water quality.
- Compare benefits and risks associated with chemicals.
- Evaluate the economic, social, and ethical issues related to biotechnology.

Science – Grade 8

Learners will study natural and technological systems. All goals should focus on the unifying concepts of science defined by the *National Science Education Standards*: Systems, Order, and Organization; Evidence, Models, and Explanation; Constancy, Change, and Measurement; Evolution and Equilibrium; and Form and Function. The skills of inquiry and technological design are targeted for mastery. The concepts for which in-depth studies should be designed at eighth grade level include: Scientific Inquiry, Technological Design, Hydrosphere, Chemistry, Evolution Theory and Cellular Biology.

Strands: The Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives Strands provide the context for content goals.

COMPETENCY GOAL 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.

Objectives

1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.

1.02 Develop appropriate experimental procedures for:
- Given questions.
- Student generated questions.

1.03 Apply safety procedures in the laboratory and in field studies:
- Recognize potential hazards.
- Safely manipulate materials and equipment.
- Conduct appropriate procedures.

1.04 Analyze variables in scientific investigations:
- Identify dependent and independent.
- Use of a control.
- Manipulate.
- Describe relationships between.
- Define operationally.

1.05 Analyze evidence to:
- explain observations.
- make inferences and predictions.
- develop the relationship between evidence and explanation.

1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
- Measurement.
- Analysis of data.
- Graphing.
- Prediction models.

1.07 Prepare models and/or computer simulations to:
- Test hypotheses.
- Evaluate how data fit.
- Make predictions.

1.08 Use oral and written language to:
- Communicate findings.
- Defend conclusions of scientific investigations.
- Describe strengths and weaknesses of claims, arguments, and/or data

1.09 Use technologies and information systems to:
- Research.
- Gather and analyze data.
- Visualize data.
- Disseminate findings to others.

1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing:
- Scientific text.
- Articles.
- Events in the popular press.

COMPETENCY GOAL 2: The learner will demonstrate an understanding of technological design.

Objectives

2.01 Explore evidence that "technology" has many definitions.
- Artifact or hardware.
- Methodology or technique.
- System of production.
- Social-technical system.

2.02 Use information systems to:
- Identify scientific needs, human needs, or problems that are subject to technological solution.
- Locate resources to obtain and test ideas.

2.03 Evaluate technological designs for:
- Application of scientific principles.
- Risks and benefits.
- Constraints of design.
- Consistent testing protocols.

2.04 Apply tenets of technological design to make informed consumer decisions about:
- Products.
- Processes.
- Systems.

COMPETENCY GOAL 3: **The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of the hydrosphere.**

Objectives

3.01 Analyze the unique properties of water including:
- Universal solvent.
- Cohesion and adhesion.
- Polarity.
- Density and buoyancy.
- Specific heat.

3.02 Explain the structure of the hydrosphere including:
- Water distribution on earth.
- Local river basin.
- Local water availability.

3.03 Evaluate evidence that Earth's oceans are a reservoir of nutrients, minerals, dissolved gases, and life forms:
- Estuaries.
- Marine ecosystems.
- Upwelling.
- Behavior of gases in the marine environment.
- Value and sustainability of marine resources.
- Deep ocean technology and understandings gained.

3.04 Describe how terrestrial and aquatic food webs are interconnected.

3.05 Analyze hydrospheric data over time to predict the health of a water system including:
- Temperature.
- Dissolved oxygen.
- pH.
- Nitrates.
- Turbidity.
- Bio-indicators.

3.06 Evaluate technologies and information systems used to monitor the hydrosphere.

3.07 Describe how humans affect the quality of water:
- Point and non-point sources of water pollution in North Carolina.
- Possible effects of excess nutrients in North Carolina waters.
- Economic trade-offs.
- Local water issues.

3.08 Recognize that the good health of environments and organisms requires:
- Monitoring of the hydrosphere.
- Water quality standards.
- Methods of water treatment.
- Maintaining safe water quality.
- Stewardship.

COMPETENCY GOAL 4: The learner will conduct investigations and utilize technology and information systems to build an understanding of chemistry.

Objectives

4.01 Understand that both naturally occurring and synthetic substances are chemicals.

4.02 Evaluate evidence that elements combine in a multitude of ways to produce compounds that account for all living and nonliving substances.

4.03 Explain how the periodic table is a model for:
- Classifying elements .
- Identifying the properties of elements.

4.04 Describe the suitability of materials for use in technological design:
- Electrical Conductivity.
- Density.
- Magnetism.
- Solubility.
- Malleability.

4.05 Identify substances based on characteristic physical properties:
- Density.
- Boiling/Melting points.
- Solubility.
- Chemical reactivity.
- Specific heat.

4.06 Describe and measure quantities related to chemical/physical changes within a system:
- Temperature.
- Volume.
- Mass.
- Precipitate.
- Gas production.

4.07 Identify evidence supporting the law of conservation of matter.
- During an ordinary chemical reaction matter cannot be created or destroyed.
- In a chemical reaction, the total mass of the reactants equals the total mass of the products.

4.08 Identify evidence that some chemicals may contribute to human health conditions including:
- Cancer.
- Autoimmune disease.
- Birth defects.
- Heart disease.
- Diabetes.
- Learning and behavioral disorders.
- Kidney disease.
- Asthma.

4.09 Describe factors that determine the effects a chemical has on a living organism including:
- Exposure.
- Potency.
- Dose and the resultant concentration of chemical in the organism.
- Individual susceptibility.
- Possible means to eliminate or reduce effects.

4.10 Describe risks and benefits of chemicals including:
- Medicines.
- Food preservatives.
- Crop yield.
- Sanitation.

COMPETENCY GOAL 5: **The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of evidence of evolution in organisms and landforms.**

Objectives

5.01 Interpret ways in which rocks, fossils, and ice cores record Earth's geologic history and the evolution of life including:
- Geologic Time Scale.
- Index Fossils.
- Law of Superposition.
- Unconformity.
- Evidence for climate change.
- Extinction of species.
- Catastrophic events.

5.02 Correlate evolutionary theories and processes:
- Biological.
- Geological.
- Technological.

5.03 Examine evidence that the geologic evolution has had significant global impact including:
- Distribution of living things.
- Major geological events.
- Mechanical and chemical weathering.

5.04 Analyze satellite imagery as a method to monitor Earth from space:
- Spectral analysis.
- Reflectance curves.

5.05 Use maps, ground truthing and remote sensing to make predictions regarding:
- Changes over time.
- Land use.
- Urban sprawl.
- Resource management.

COMPETENCY GOAL 6: The learner will conduct investigations, use models, simulations, and appropriate technologies and information systems to build an understanding of cell theory.

Objectives

6.01 Describe cell theory:
- All living things are composed of cells.
- Cells provide structure and carry on major functions to sustain life.
- Some organisms are single cell; other organisms, including humans, are multi-cellular.
- Cell function is similar in all living things.

6.02 Analyze structures, functions, and processes within animal cells for:
- Capture and release of energy.
- Feedback information.
- Dispose of wastes.
- Reproduction.
- Movement.
- Specialized needs.

6.03 Compare life functions of protists:
- Euglena.
- Amoeba.
- Paramecium.
- Volvox.

6.04 Conclude that animal cells carry on complex chemical processes to balance the needs of the organism.
- Cells grow and divide to produce more cells.
- Cells take in nutrients to make the energy for the work cells do.
- Cells take in materials that a cell or an organism needs.

COMPETENCY GOAL 7: The learner will conduct investigations, use models, simulations, and appropriate technologies and information systems to build an understanding of microbiology.

Objectives

7.01 Compare and contrast microbes:
- Size, shape, structure.
- Whether they are living cells.

7.02 Describe diseases caused by microscopic biological hazards including:
- Viruses.
- Bacteria.
- Parasites.
- Contagions.
- Mutagens.

7.03 Analyze data to determine trends or patterns to determine how an infectious disease may spread including:
- Carriers.
- Vectors.
- Conditions conducive to disease.
- Calculate reproductive potential of bacteria.

7.04 Evaluate the human attempt to reduce the risk of and treatments for microbial infections including:
- Solutions with anti-microbial properties.
- Antibiotic treatment.
- Research.

7.05 Investigate aspects of biotechnology including:
- Specific genetic information available.
- Careers.
- Economic benefits to North Carolina.
- Ethical issues.
- Impact for agriculture.

High School Courses Grades 9-12

Courses

- Biology
- Chemistry
- Earth/Environmental Science
- Physical Science
- Physics
- AP Science Courses

The Unifying Concepts of Science

The high school science component of the *SCS* focuses on the unifying concepts of science as identified by the *National Science Education Standards*. The unifying concepts and the strands should be integrated with the science content goals and objectives for high school. The unifying concepts of science consist of:

- Systems, Order, and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Strands

The strands include the following goals: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives.

Nature of Science

As a result of activities in grades 9 - 12, all students should develop an understanding of:

- Science as a human endeavor.
- Nature of scientific knowledge.
- Historical perspectives.

Science as Inquiry

As a result of activities in grades 9 - 12, all students should develop:

- constructing hypotheses.
- The ability to do scientific inquiry.
- Understanding about scientific inquiry.
- Abilities to perform safe and appropriate manipulation of materials, equipment, and technologies.
- Mastery of integrated process skills.
    - constructing hypotheses.
    - acquiring, processing, and interpreting data.
    - identifying variables and their relationships.
    - designing investigations.
    - experimenting.
    - analyzing investigations.
    - formulating models.

Science and Technology

As a result of activities in grades 9 - 12, all students should develop:

- An understanding of technology.
- The ability to perform technological design.
- An understanding of the connection between science and technology.

Science in Personal and Social Perspectives

As a result of activities in grades 9 - 12, all students should develop an understanding of:

- Personal and community health.
- Population growth.
- Natural resources.
- Environmental quality.
- Natural and human-induced hazards.
- Science and technology in local, national, and global challenges.
- Careers in science and technology.

BIOLOGY

Goals

The biology curriculum is designed to continue student investigations and deepen student understanding of the biological sciences. High school instruction should include concepts introduced in grades K-8 at a more abstract level. In-depth study of the following concepts is included: the cell, the molecular basis of heredity, biological evolution, the interdependence of organisms, matter, energy and organization in living systems, and the adaptive responses of organisms. For instruction, the program strands and unifying concepts should be woven through the content goals and objectives of the course. The following explanation introduces teachers to the program strands and unifying concepts. Supplemental materials, providing a more detailed explanation of the goals, objectives, unifying concepts and program strands, with specific recommendations for classroom and/or laboratory implementation, are available through the Department of Public Instruction's Publications Section.

Unifying Concepts

The following unifying concepts should unite the study of various biological topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Focus on the unifying concepts of science will also help students to understand the constant nature of science across disciplines and time even as scientific knowledge, understanding and procedures change.

Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. This strand is designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Biology is rich in examples of science as a human endeavor, its historical perspectives, and the development of scientific understanding. As concepts are developed this strand can be interwoven to create an in-depth understanding.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be implemented by designing instruction that encourages students to work collaboratively in groups, to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in biology provides an opportunity to present science as the basis for medicine, ecology, forensics, biotechnology, and environmental studies. The diverse biology content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a biology background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge–building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. For example, from Mendel's story, to the work of Watson and Crick, to modern breakthroughs in gene manipulation for therapeutic purposes, history illustrates every important facet of the nature of science.

As students explore original writing by and about scientists, they will uncover human drama, such as the obscurity of Mendel's work until after his death, and the interpersonal struggles involved in the discovery of DNA. They will understand that knowledge generated by one generation maybe is expanded, modified, or even discarded by the next generation.

Nature of Scientific Knowledge

Much of what is understood about the nature of science must be explicitly addressed:

- All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.
- Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories become stronger as more supporting evidence is gathered. They provide a context for further research and give us a basis for prediction. For example, the theory of biological evolution is an explanation for phenomena such as the diversity of species, the genetic relationships between species and the fossil record. Gene theory is an explanation for relationships we observe between one generation and the next.
- Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p. 201)

Science as Inquiry

Inquiry should be the central theme in biology. Inquiry is an integral part of the learning experience and may be used in both traditional class problems and laboratory experiences. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned.

Inquiry is the application of creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful. Classical experiments confirming well-accepted scientific principles may be necessary to reinforce constructed understandings and to teach safe and proper use of laboratory techniques and instruments, but they should not be the whole laboratory experience.

Instead, laboratory experience should provide a foundation for exploring new questions. In biology, for example, traditional labs such as dissection and observation of plant and animal cells may be quite appropriate. They should, however, lead to open-ended explorations such as the study of a particular animal's anatomy in relation to its environment and behavior, or the effect of changing environmental conditions on the growth of yeast (or other) cells. These kinds of activities teach student how science is done - how to clarify questions, how to design and experiment, how to record and display data, how to communicate knowledge generated. If this time investment means that a memorization of the parts of the cells and their function is left undone, consider the long-term value for students and make the necessary trade-offs. A student can always consult a book if he/she needs to know about a cell organelle, but a book will not provide the experience of generating new knowledge through scientific exploration.

Biology provides potential for many inquiries. "Does the earthworm respond to light?" "Why?" "Does temperature affect the metabolic activity of yeast?" "Why?" The process of inquiry, experimental design, investigation, and analysis is as important as finding the correct answer. Students will master much more than facts and manipulative skills; they will learn to be critical thinkers.

A solid conceptual base of scientific principles, as well as knowledge of science safety is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science and Technology

It would be impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology.

The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life. Technological design plays an important role in building knowledge in biology. For example, electron microscopes, graphing calculators, personal computers, and magnetic resonance images have changed our lives, increased our knowledge of biology, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand is designed to help students formulate basic understanding and implied actions for many issues facing our society. The fundamental concepts that form the basis for this strand include:

Personal and Community Health

Biology is an excellent context for investigating the factors that affect the health of organisms in general and humans in specific. Persuading adolescents to adopt personal habits that contribute to long-term health is not always easy. Looking at issues such as nutrition, exercise, rest, and substance abuse from the perspective of an organism's needs and responses provides a less emotional atmosphere for considering health issues relevant to teenagers.

Population Growth

Biology students should develop the ability to assess the carrying capacity of a given environment and its implied limits on population growth, as well as how technology allows environmental modifications to adjust its carrying capacity.

Environmental Quality

The role of biological sciences is particularly relevant to areas where humans affect and are affected by other organisms and the non-living environment. The curriculum offers opportunities for students to make decisions based on evidence in the areas of environmental stewardship and economic realities.

Science and Technology in Local, National, and Global Challenges

This part of the science in personal and social perspectives strand examines the involvement of human decisions in the use of scientific and technological knowledge. “Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.” (National Science Education Standards, 1996, p. 199) The *NSES* emphasizes that “students should understand the appropriateness and value of basic questions ‘What can happen?’ - ‘What are the Odds?’- and ‘How do scientists and engineers know what will happen?’” (p. 199) Students should understand the causes and extent of science-related challenges. They should become familiar with the advances and improvements that proper application of scientific principles and products has brought to environmental enhancement, wise energy use, reduced vehicle emissions, and improved human health.

BIOLOGY - Grades 9-12

Learners will study biological systems. The strands and unifying concepts provide a context for teaching content and process skill goals. Instruction should focus on the following unifying concepts:

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, and Science in Personal and Social Perspectives. They provide the context for teaching of the content goals and objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Identify biological questions and problems that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer biological questions.
- Create testable hypotheses
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models of biological phenomena using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations from an informed, scientifically-literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will develop an understanding of the physical, chemical and cellular basis of life.

Objectives

2.01 Compare and contrast the structure and functions of the following organic molecules:
- Carbohydrates.
- Proteins.
- Lipids.
- Nucleic acids.

2.02 Investigate and describe the structure and functions of cells including:
- Cell organelles.
- Cell specialization.
- Communication among cells within an organism.

2.03 Investigate and analyze the cell as a living system including:
- Maintenance of homeostasis.
- Movement of materials into and out of cells.
- Energy use and release in biochemical reactions.

2.04 Investigate and describe the structure and function of enzymes and explain their importance in biological systems.

2.05 Investigate and analyze the bioenergetic reactions:
- Aerobic Respiration.
- Anaerobic Respiration.
- Photosynthesis.

COMPETENCY GOAL 3: The learner will develop an understanding of the continuity of life and the changes of organisms over time.

Objectives

3.01 Analyze the molecular basis of heredity including:
- DNA replication.
- Protein synthesis (transcription, translation).
- Gene regulation.

3.02 Compare and contrast the characteristics of asexual and sexual reproduction.

3.03 Interpret and predict patterns of inheritance.
- Dominant, recessive and intermediate traits.
- Multiple alleles.
- Polygenic inheritance.
- Sex-linked traits.
- Independent assortment.
- Test cross.
- Pedigrees.
- Punnett squares.

3.04 Assess the impact of advances in genomics on individuals and society.
- Human genome project.
- Applications of biotechnology.

3.05 Examine the development of the theory of evolution by natural selection including:
- Development of the theory.
- The origin and history of life.
- Fossil and biochemical evidence.
- Mechanisms of evolution.
- Applications (pesticide and antibiotic resistance).

COMPETENCY GOAL 4: The learner will develop an understanding of the unity and diversity of life.

Objectives

4.01 Analyze the classification of organisms according to their evolutionary relationships.
- The historical development and changing nature of classification systems.
- Similarities and differences between eukaryotic and prokaryotic organisms.
- Similarities and differences among the eukaryotic kingdoms: Protists, Fungi, Plants, Animals.
- Classify organisms using keys.

4.02 Analyze the processes by which organisms representative of the following groups accomplish essential life functions including:
- Unicellular protists, annelid worms, insects, amphibians, mammals, non vascular plants, gymnosperms and angiosperms.
- Transport, excretion, respiration, regulation, nutrition, synthesis, reproduction, and growth and development.

4.03 Assess, describe and explain adaptations affecting survival and reproductive success.
- Structural adaptations in plants and animals (form to function).

- Disease-causing viruses and microorganisms.
- Co-evolution.

4.04 Analyze and explain the interactive role of internal and external factors in health and disease:
- Genetics.
- Immune response.
- Nutrition.
- Parasites.
- Toxins.

4.05 Analyze the broad patterns of animal behavior as adaptations to the environment.
- Innate behavior.
- Learned behavior.
- Social behavior.

COMPETENCY GOAL 5: The learner will develop an understanding of the ecological relationships among organisms.

Objectives

5.01 Investigate and analyze the interrelationships among organisms, populations, communities, and ecosystems.
- Techniques of field ecology.
- Abiotic and biotic factors.
- Carrying capacity.

5.02 Analyze the flow of energy and the cycling of matter in the ecosystem
- Relationship of the carbon cycle to photosynthesis and respiration.
- Trophic levels - direction and efficiency of energy transfer.

5.03 Assess human population and its impact on local ecosystems and global environments:
- Historic and potential changes in population.
- Factors associated with those changes.
- Climate change.
- Resource use.
- Sustainable practices/stewardship.

CHEMISTRY

Goals

The chemistry course encourages students to continue their investigation of the structure of matter along with chemical reactions and the conservation of energy in these reactions. Inquiry is applied to the study of the transformation, composition, structure, and properties of substances. The course focuses on basic chemical concepts and incorporates activities that promote investigations to reinforce the concepts. The curriculum includes inquiry into the following content areas:

- Structure of atoms.
- Structure and properties of matter.
- Chemical reactions.
- Conservation of energy and matter.
- Interaction of energy and matter.

The following explanation introduces teachers to the unifying concepts and program strands. During instruction these concepts should be woven through the content goals and objectives of the course. Supplemental materials providing a more detailed explanation of the goals, objectives, and strands, with specific recommendations for classroom and/or laboratory implementation are available through the Department of Public Instruction's Publications Section.

Unifying Concepts

Unifying Concepts should unite the study of various chemical topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Focus on the unifying concepts of science will also help students to understand the constant nature of science across disciplines and time even as scientific knowledge, understanding and procedures change.

Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Chemistry is rich in examples of science as a human endeavor, historical perspectives on the development of scientific knowledge, and the nature and role of scientific knowledge.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be taught by designing instruction that encourages students to work in groups, design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in chemistry provides an opportunity to present science as the basis for engineering, ecology, computer science, health sciences and the technical trades. The diversity of chemistry content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a chemistry background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances.

A historical view from the philosophical perspective of Democritus (who produced no experimental evidence) to the genius of Dalton's inferences from his observation of gases, make chemistry come alive. In other examples, the history of Aristotle's philosophy of matter, and of Dalton's and Bohr's models of atomic theory, emphasize the value of a scientific model in enabling researchers to explore an unseen entity by starting with certain assumptions posited by the model.

Nature of Scientific Knowledge

Much of what is understood about the nature of science must be addressed explicitly.

- All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.
- Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories become stronger as more supporting evidence is gathered. They provide a context for further research and give us a basis for prediction. For example, atomic theory is an explanation for the behavior of matter based on the existence of tiny particles. Kinetic molecular theory explains, among other things, the expansion and contraction of gases.
- Laws are fundamentally different from theories. They are universal generalizations based on observations we have made of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p. 201)

Science as Inquiry

Inquiry should be the central theme in chemistry. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory work. Because of the unique safety issues that arise in the chemistry lab, students must be given well-supervised experience in basic laboratory techniques, including safe use of materials and equipment. However, the essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting help students build knowledge and communicate what they have learned.

Inquiry applies creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuition have been successful. Classical experiments confirming well-accepted scientific principles may be necessary to reinforce constructed understandings and to teach safe and proper use of laboratory techniques and instruments, but they should not be the whole laboratory experience. Instead, laboratory experience should be a foundation for exploring new questions. Experiments such as measurement of physical properties, decomposition of compounds, and observation of the behavior of gases should be preliminary to open-ended investigations in which students are charged with posing questions, designing experiments, recording and displaying data, and communicating. For example, after measuring physical properties, students might investigate the relationship between the density of certain liquids and their boiling points. Although original research by students traditionally has been relegated to a yearly science fair project, ongoing student involvement in this process contributes to their understanding of scientific enterprise and to their problem-solving abilities.

A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science and Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology.

The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life.

The relationship between science and technology is easily seen in the discipline of chemistry. Technological design plays an important role in building chemistry knowledge. For example, electron microscopes, super-colliders, personal computers, and spectroscopes have changed our lives, increased our knowledge of chemistry, and improved our understanding of the universe. As students explore chemistry from a historical perspective, they can easily investigate the technology that contributed to knowledge in specialized areas. A relevant assignment might ask students to identify the technology used by researchers in exploring the atom and the relationships of the technology to the sophistication of the knowledge gained. Another assignment might be for students to compare the relative simplicity of Rutherford's gold foil apparatus to the space-age technology of modern super-colliders. Interviews with scientists and technicians in all areas of chemistry could provide a rich listing of the newest research instruments and the kinds of questions they seek to answer.

Science in Personal and Social Perspectives

This strand is designed to help students formulate basic understandings and implied actions for many current issues facing our society. Many examples of chemistry affecting personal and social issues can be found to help students understand the importance and applications of chemical knowledge.

Environmental Quality

Studies indicate that the general public associates "chemicals" with materials that may harm humans and/or the environment. For that reason, it is particularly important to lead students to approach such issues scientifically. There are, obviously, both negative and positive impacts from man-made chemicals, and students can gain much from conducting cost/benefit analyses of selected uses.

Such tasks emphasize the use of evidence in decision-making, a skill that transfers to every aspect of students' lives.

There are many available resources that promote one point of view or another about the use of chemicals. Having students analyze such materials for accuracy, possible bias, and misleading statements equips them to make decisions as consumers and voters. Scientists from local industries or colleges and universities can provide excellent help in evaluating such publications and, at the same time, provide information about careers in chemistry.

Science and Technology in Local, National, and Global Challenges -

This aspect of the science in personal and social perspectives strand encourages examination of the involvement of human decisions in the application of scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges." "Students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the Odds?'- and, 'How do scientists and engineers know what will happen?'" (NSES, p. 199). The NSES emphasizes that students should understand the causes and extent of science-related challenges. They should become familiar with the advances and improvements that proper application of scientific principles and products has brought to environmental enhancement, wise energy use, reduced vehicle emissions, and improved human health.

CHEMISTRY - Grades 9-12

The Chemistry course encourages students to continue their investigations of the structure of matter along with chemical reactions and the conservation of matter and energy in those reactions. Inquiry is applied to the study of the composition, structure, properties and transformation of substances. The course focuses on basic chemical concepts and incorporates investigations to build understanding of these concepts. The unifying concepts and program strands provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content goals and objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Design, conduct and analyze investigations to answer questions related to chemistry.
- Identify questions and suggest hypotheses.
- Identify variables.
- Use a control when appropriate.
- Select and use appropriate measurement tools.
- Collect and organize data in tables, charts and graphs.
- Analyze and interpret data.
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.
- Identify how scientists share findings.

1.02 Analyze reports of scientific investigations from an informed scientifically-literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data

1.03 Analyze experimental designs with regard to safety and use safe procedures in laboratory investigations:
- Identify and avoid potential safety hazards given a scenario.
- Differentiate between safe and unsafe procedures.
- Use information from the MSDS (Material Safety Data Sheets) to assess chemical hazards.

COMPETENCY GOAL 2: The learner will build an understanding of the structure and properties of matter.

Objectives

2.01 Analyze the historical development of the current atomic theory.
- Early contributions: Democritus and Dalton.
- The discovery of the electron: Thomson and Millikan.
- The discovery of the nucleus, proton and neutron: Rutherford and Chadwick.
- The Bohr model.
- The quantum mechanical model.

2.02 Examine the nature of atomic structure.
- Subatomic particles: protons, neutrons, and electrons.
- Mass number.
- Atomic number.
- Isotopes.

2.03 Apply the language and symbols of chemistry.
- Name compounds using the IUPAC conventions.
- Write formulas of simple compounds from their names.

2.04 Identify substances using their physical properties:
- Melting points.
- Boiling points.
- Density.
- Solubility.

2.05 Analyze the basic assumptions of kinetic molecular theory and its applications:
- Ideal Gas Equation.
- Combined Gas Law.
- Dalton's Law of Partial Pressures.

2.06 Assess bonding in metals and ionic compounds as related to chemical and physical properties.

2.07 Assess covalent bonding in molecular compounds as related to molecular geometry and chemical and physical properties.

- Molecular.
- Macromolecular.
- Hydrogen bonding and other intermolecular forces (dipole/dipole interaction, dispersion).
- VSEPR theory.

2.08 Assess the dynamics of physical equilibria.
- Interpret phase diagrams.
- Factors that affect phase changes.

COMPETENCY GOAL 3: The learner will build an understanding of regularities in chemistry.

Objectives

3.01 Analyze periodic trends in chemical properties and use the periodic table to predict properties of elements.
- Groups (families).
- Periods.
- Representative elements (main group) and transition elements.
- Electron configuration and energy levels.
- Ionization energy.
- Atomic and ionic radii.
- Electronegativity.

3.02 Apply the mole concept, Avogadro's number and conversion factors to chemical calculations.
- Particles to moles.
- Mass to moles.
- Volume of a gas to moles.
- Molarity of solutions.
- Empirical and molecular formula.
- Percent composition.

3.03 Calculate quantitative relationships in chemical reactions (stoichiometry).
- Moles of each species in a reaction.
- Mass of each species in a reaction.
- Volumes of gaseous species in a reaction.

COMPETENCY GOAL 4: The learner will build an understanding of energy changes in chemistry.

Objectives

4.01 Analyze the Bohr model in terms of electron energies in the hydrogen atom.
- The spectrum of electromagnetic energy.
- Emission and absorption of electromagnetic energy as electrons change energy levels.

4.02 Analyze the law of conservation of energy, energy transformation, and various forms of energy involved in chemical and physical processes.
- Differentiate between heat and temperature.
- Analyze heating and cooling curves.
- Calorimetry, heat of fusion and heat of vaporization calculations.
- Endothermic and exothermic processes including interpretation of potential energy.
- Diagrams (energy vs reaction pathway), enthalpy and activation energy.

4.03 Analyze the relationship between entropy and disorder in the universe.

4.04 Analyze nuclear energy.
- Radioactivity: characteristics of alpha, beta and gamma radiation.
- Decay equations for alpha and beta emission.
- Half-life.
- Fission and fusion.

COMPETENCY GOAL 5: The learner will develop an understanding of chemical reactions.

Objectives

5.01 Identify various types of chemical reactions:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.
- Combustion of hydrocarbons.

5.02 Apply the law of conservation of matter to the balancing of chemical equations.

5.03 Identify the indicators of chemical change:
- Formation of a precipitate.
- Evolution of a gas.
- Color change.
- Absorption or release of heat.

5.04 Identify the physical and chemical behaviors of acids and bases.
- General properties of acids and bases.
- Concentration and dilution of acids and bases.
- Ionization and the degree of dissociation (strengths) of acids and bases.
- Indicators.
- Acid-base titration.
- pH and pOH.

5.05 Analyze oxidation/reduction reactions with regard to the transfer of electrons.
- Assign oxidation numbers to elements in REDOX reactions
- Identify the elements oxidized and reduced.
- Write simple half reactions.
- Assess the practical applications of oxidation and reduction reactions.

5.06 Assess the factors that affect the rates of chemical reactions.
- The nature of the reactants.
- Temperature.
- Concentration.
- Surface area.
- Catalyst.

EARTH/ENVIRONMENTAL SCIENCE

Goals

The Earth/Environmental science curriculum focuses on the function of Earth's systems. Emphasis is placed on matter, energy, plate tectonics, origin and evolution of the earth and solar system, environmental awareness, materials availability, and the cycles that circulate energy and material through the earth system. This section introduces teachers to the program strands and unifying concepts. During instruction, these concepts should be woven through the content goals and objectives of the course. Supplemental materials providing a more detailed explanation of the goals, objectives, and strands, with specific recommendations for classroom and/or laboratory implementation are available through the Department of Public Instruction's Publications Section.

Unifying Concepts

The following unifying concepts should unite the study of various Earth and environmental topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Nature of Science

This strand is divided into three sections: Science as a human endeavor, historical perspectives, and the nature of scientific inquiry. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. The earth and environmental sciences are rich in examples of science as a human endeavor, its historical perspectives, and the development of scientific understanding.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be taught by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in Earth/Environmental science is an opportunity to present science as the basis for civil engineering, mining, geology, oceanography, astronomy, and the environmental technical trades. The content diversity lets us look at science as a vocation. Scientist and technician are just two of the many careers in which an earth and environmental sciences background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. Some examples are Eratosthenes' determination of the size of the earth, Wegener's apparent "fit" of the continents, Kepler's laws of planetary motion, and James Hutton's simple yet powerful idea that Earth's history must be explained by what we see happening now. Today, Hutton's uniformity of process principle is used to interpret the structure of landing sites on Mars.

Nature of Scientific Knowledge

Much of what is understood about the nature of science must be explicitly addressed:

- All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.
- Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories become stronger as more supporting evidence is gathered. They may be modified as new data is gathered or existing data is interpreted in different ways. They provide a context

for further research and give us a basis for prediction. For example, the Theory of Plate Tectonics explains the movement of lithospheric plates.

- Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p. 201)

Science as Inquiry

Inquiry should be the central theme in earth/environmental science. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory experiences. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting help students build knowledge and communicate what they have learned. Inquiry applies creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful. For example, traditional labs, which emphasize observation of the sun or identification and classification of sediments, may be quite appropriate. These labs should, however, lead to open-ended explorations such as investigation of sun spot activity or the factors that influence the sorting of sediments. Although original student research has often been relegated to a yearly science fair project, continuing student research contributes immensely to understanding of the process of science and to problem-solving abilities. Earth/Environmental science provides many opportunities for inquiry. "Why does the location of sunrise or sunset change through the year?" "Why are sedimentary rock layers tipped at an angle?" "Why do sunspots move faster near the sun's equator?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will acquire much more than facts and manipulative skills; they will learn to be critical thinkers.

A solid conceptual base of scientific principles, as well as knowledge of science safety is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science And Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology. The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life. Technological design plays an important role in earth/environmental science. For example, telescopes, lasers, satellites, transistors, graphing calculators, personal computers, and seismographs have changed our lives, increased our knowledge of earth/environmental science, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand helps students formulate a basic understanding of and implied actions for many issues facing our society. The fundamental concepts that form the basis for this strand include:

- Environmental Quality - Students should develop an appreciation for factors that influence their need and responsibility to maintain environmental quality, including waste disposal and recycling of limited natural resources. The ability to make appropriate decisions based on cost-benefit and risk analysis is an integral part of the study of earth and environmental science. "Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth." (National Science Education Standards, 1996, p. 198).
- Natural and Human -Induced Hazards - The study of earth and environmental science encourages students to investigate the effects of natural phenomena and human induced changes in natural systems on society. Appropriate examples include natural phenomena such as earthquakes and human-induced changes such as increased carbon dioxide in the atmosphere. Students will acquire the ability to assess natural and human induced hazards - ranging from relatively minor risks to catastrophic events with major risk, as well as the accuracy with which these events can be predicted. It is particularly important for students to relate such phenomena to North Carolina and its citizens.
- Science and Technology in Local, National, and Global Challenges - Along with the need to understand the causes and extent of environmental challenges related to natural and man-made phenomena, students should become familiar with the advances proper application of scientific principles and products have brought to environmental enhancements. Topics such as improved energy use, reduced vehicle emissions, and improved crop yields are just some examples of how the proper application of science has improved the quality of life. This strand will help students make rational decisions in the use of

scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges." (NSES, 1996, p. 199). The *NSES* emphasize that students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' - and 'How do scientists and engineers know what will happen?'" (NSES, 1996, p. 199).

EARTH/ENVIRONMENTAL SCIENCE Grades 9-12

The Earth/Environmental science curriculum focuses on the function of Earth's systems. Emphasis is placed on matter, energy, plate tectonics, environmental awareness, materials availability, and the cycles that circulate energy and material through the earth system. Learners will study natural and technological systems. The program strands and unifying concepts provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry in the earth and environmental sciences.

Objectives

1.01 Identify questions and problems in the earth and environmental sciences that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer questions related to earth and environmental science.
- Create testable hypotheses
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Evaluate the uses of satellite images and imaging techniques in the earth and environmental sciences.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations and environmental issues from an informed scientifically literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

1.06 Identify and evaluate a range of possible solutions to earth and environmental issues at the local, national, and global level including considerations of:
- Interdependent human and natural systems.
- Diverse perspectives.
- Short and long range impacts.
- Economic development, environmental quality and sustainability.
- Opportunities for and consequences of personal decisions.
- Risks and benefits of technological advances.

COMPETENCY GOAL 2: The learner will build an understanding of lithospheric materials, tectonic processes, and the human and environmental impacts of natural and human-induced changes in the lithosphere.

Objectives

2.01 Analyze the dependence of the physical properties of minerals on the arrangement and bonding of their atoms.

2.02 Analyze the historical development of the theory of plate tectonics.

2.03 Investigate and analyze the processes responsible for the rock cycle:
- Analyze the origin, texture and mineral composition of rocks.
- Trace the path of elements through the rock cycle.
- Relate rock formation to plate tectonics.
- Identify forms of energy that drive the rock cycle.
- Analyze the relationship between the rock cycle and processes in the atmosphere and hydrosphere.

2.04 Analyze seismic waves including velocity and refraction to:
- Infer Earth's internal structure.
- Locate earthquake epicenters.
- Measure earthquake magnitude.
- Evaluate the level of seismic activity in North Carolina.

2.05 Create and interpret topographic, soil and geologic maps using scale and legends.

2.06 Investigate and analyze the importance and impact of the economic development of earth's finite rock, mineral, soil, fossil fuel and other natural resources to society and our daily lives:
- Availability.
- Geographic distribution.
- Conservation/Stewardship.
- Recycling.
- Environmental impact.
- Challenge of rehabilitation of disturbed lands.

2.07 Analyze the sources and impacts of society's use of energy.
- Renewable and non-renewable sources.
- The impact of human choices on Earth and its systems.

COMPETENCY GOAL 3: The learner will build an understanding of the origin and evolution of the earth system.

Objectives

3.01 Assess evidence to interpret the order and impact of events in the geologic past:
- Relative and absolute dating techniques.
- Statistical models of radioactive decay.
- Fossil evidence of past life.
- Uniformitarianism.
- Stratigraphic principles.
- Divisions of Geologic Time
- Origin of the earth system.
- Origin of life.

3.02 Evaluate the geologic history of North Carolina.

COMPETENCY GOAL 4: The learner will build an understanding of the hydrosphere and its interactions and influences on the lithosphere, the atmosphere, and environmental quality.

Objectives

4.01 Evaluate erosion and depositional processes:
- Formation of stream channels with respect to the work being done by the stream (i.e. down-cutting, lateral erosion, and transportation).
- Nature and characteristics of sediments.
- Effects on water quality.
- Effect of human choices on the rate of erosion.

4.02 Analyze mechanisms for generating ocean currents and upwelling:
- Temperature.
- Coriolis effect.
- Climatic influence.

4.03 Analyze the mechanisms that produce the various types of shorelines and their resultant landforms:
- Nature of underlying geology.
- Long and short term sea-level history.
- Formation and breaking of waves on adjacent topography.
- Human impact.

4.04 Evaluate water resources:
- Storage and movement of groundwater.
- Ecological services provided by the ocean
- Environmental impacts of a growing human population.
- Causes of natural and manmade contamination.

4.05 Investigate and analyze environmental issues and solutions for North Carolina's river basins, wetlands, and tidal environments:
- Water quality.
- Shoreline changes.
- Habitat preservation.

COMPETENCY GOAL 5: The learner will build an understanding of the dynamics and composition of the atmosphere and its local and global processes influencing climate and air quality.

Objectives

5.01 Analyze air masses and the life cycle of weather systems:
- Planetary wind belts.
- Air masses.
- Frontal systems.
- Cyclonic systems.

5.02 Evaluate meteorological observing, analysis, and prediction:
- Worldwide observing systems.
- Meteorological data depiction.

5.03 Analyze global atmospheric changes including changes in CO_2, CH_4, and stratospheric O_3 and the consequences of these changes:
- Climate change.
- Changes in weather patterns.
- Increasing ultraviolet radiation.
- Sea level changes.

COMPETENCY GOAL 6: The learner will acquire an understanding of the earth in the solar system and its position in the universe.

Objectives

6.01 Analyze the theories of the formation of the universe and solar system.

6.02 Analyze planetary motion and the physical laws that explain that motion:
- Rotation.
- Revolution.
- Apparent diurnal motions of the stars, sun and moon.
- Effects of the tilt of the earth's axis.

6.03 Examine the sources of stellar energies.
- Life cycle of stars.
- Hertzsprung – Russell Diagram.

6.04 Assess the spectra generated by stars and our sun as indicators of motion and composition (the Doppler effect).

6.05 Evaluate astronomers' use of various technologies to extend their senses:
- Optical telescopes.
- Cameras.
- Radio telescopes.
- Spectroscope.

PHYSICAL SCIENCE

Goals

The Physical Science curriculum is designed to continue the investigation of the physical sciences begun in earlier grades. The Physical Science course will build a rich knowledge base to provide a foundation for the continued study of science. The investigations should be approached in a qualitative and quantitative manner in keeping with the developing mathematical skills of the students. The curriculum will integrate the following topics from both chemistry and physics:

- Structure of atoms
- Structure and properties of matter
- Motions and forces
- Conservation of energy, matter and charge

The following explanation introduces teachers to the program strands and unifying concepts. During instruction, these strands and unifying concepts should be woven through the content goals and objectives of the course. Supplemental materials providing a more detailed explanation of the goals, objectives, and strands, with specific recommendations for classroom and/or laboratory implementation are available through the Department of Public Instruction's Publications Section.

Unifying Concepts -

Unifying Concepts the following unifying concepts should unite the study of various physical science topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Focus on the unifying concepts of science will also help students to understand the constant nature of science across disciplines and time even as scientific knowledge, understanding and procedures change.

Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Physical science is rich in examples of science as a human endeavor, historical perspectives on the development of scientific understanding, and the nature and role of science.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be implemented by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in physical science is an opportunity to present science as a basis for engineering, electronics, computer science, astronomy and the technical trades. The diversity of physical science content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a physical science background is necessary.

Perhaps the most important aspect of this strand is that science is an integral part of society and is therefore relevant to students' lives.

Historical Perspectives

Most scientific knowledge and technological advances develop incrementally from the labors of scientists and inventors. Although science history includes accounts of serendipitous scientific discoveries, most development of scientific concepts and technological innovation occurs in response to a specific problem or conflict. Both great advances and gradual knowledge building in science and technology have profound effects on society. Students should appreciate the scientific thought and effort of the individuals who contributed to these advances. Galileo's struggle to correct the misconceptions arising from Aristotle's explanation of the behavior of falling bodies led to Newton's deductive approach to motion in *The Principia*. Today, Newton's Law of Universal Gravitation and his laws of motion are used to predict the landing sites for NASA's space flights.

Nature of Scientific Knowledge

Much of what is understood about the nature of science must be addressed explicitly:

- All scientific knowledge is tentative, although many ideas have stood the test of time and are reliable for our use.
- Theories "explain" phenomena that we observe. They are never proved; rather, they represent the most logical explanation based on currently available evidence. Theories just become stronger as more supporting evidence is gathered. They provide a context for further research and give us a basis for prediction. For example, in physical science, atomic theory explains the behavior of matter based on the existence of tiny particles. And kinetic theory explains, among other things, the expansion and contraction of gases.
- Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. The *NSES* state "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (p. 201).

Science as Inquiry

Inquiry should be the central theme in physical science. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory work. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned. Inquiry is the application of creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful.

Classical experiments such as measuring inertia and the speed of falling bodies need not be excluded. Rather, they should be a prelude to open-ended investigations in which the students have the chance to pose questions, design experiments, record and analyze data, and communicate their findings. For example, after measuring the relationships among force, mass, and acceleration of falling bodies, students might investigate the phenomenon of "weightlessness", or, after measuring physical properties, they might investigate the connection (if any) between the density of certain liquids and their boiling point.

Although original student research is often relegated to a yearly science fair project, continuing student involvement in research contributes immensely to their understanding of the process of science and to their problem-solving abilities. Physical science provides much potential for inquiries. "Does the aluminum baseball bat have an advantage over a wooden baseball bat?" "Why?" "Is one brand of golf ball better than another brand?" "Why?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will master much more than facts and acquisition of manipulative skills; they will learn to be critical thinkers.

A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science and Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology.

The methods of scientific inquiry and technological design share many common elements including objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life.

Technological design is important to building knowledge in physical science. Telescopes, lasers, transistors, graphing calculators, personal computers, and photogates, for example, have changed our lives, increased our knowledge of physical science, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand helps students in making rational decisions in the use of scientific and technological knowledge. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges. (NSES, p. 199). The *NSES* emphasizes that "students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' and 'How do scientists and engineers know what will happen?'" (NSES, p. 199). Students should understand the causes and extent of science-related challenges. They should become familiar with the advances that proper application of scientific principles and products have brought to environmental enhancement, better energy use, reduced vehicle emissions, and improved human health.

PHYSICAL SCIENCE - Grades 9-12

The Physical Science curriculum is designed to continue the investigation of the physical sciences begun in earlier grades. The Physical Science course will build a rich knowledge base to provide a foundation for the continued study of science. The investigations should be approached in both a qualitative and quantitative manner in keeping with the developing mathematical skills of the students. The unifying concepts and program strands provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function.

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Identify questions and problems that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will construct an understanding of forces and motion.

Objectives

2.01 Measure and mathematically/graphically analyze motion:
- Frame of reference (all motion is relative - there is no motionless frame).
- Uniform motion.
- Acceleration.

2.02 Investigate and analyze forces as interactions that can change motion:
- In the absence of a force, an object in motion will remain in motion or an object at rest will remain at rest until acted on by an unbalanced force.
- Change in motion of an object (acceleration) is directly proportional to the unbalanced outside force and inversely proportional to the mass.
- Whenever one object exerts a force on another, an equal and opposite force is exerted by the second on the first.

COMPETENCY GOAL 3: The learner will analyze energy and its conservation.

Objectives

3.01 Investigate and analyze storage of energy:
- Kinetic energy.
- Potential energies: gravitational, chemical, electrical, elastic, nuclear.
- Thermal energy.

3.02 Investigate and analyze transfer of energy by work:
- Force.
- Distance.

3.03 Investigate and analyze transfer of energy by heating:
- Thermal energy flows from a higher to a lower temperature.
- Energy will not spontaneously flow from a lower temperature to a higher temperature.
- It is impossible to build a machine that does nothing but convert thermal energy into useful work.

3.04 Investigate and analyze the transfer of energy by waves:
- General characteristics of waves: amplitude, frequency, period, wavelength, velocity of propagation.
- Mechanical waves.
- Sound waves.
- Electromagnetic waves (radiation).

COMPETENCY GOAL 4: The learner will construct an understanding of electricity and magnetism.

Objectives

4.01 Investigate and analyze the nature of static electricity and the conservation of electrical charge:
- Positive and negative charges.
- Opposite charges attract and like charges repel.
- Analyze the electrical charging of objects due to the transfer of charge.

4.02 Investigate and analyze direct current electrical circuits:
- Ohm's law.
- Series circuits.
- Parallel circuits.

4.03 Investigate and analyze magnetism and the practical applications of the characteristics of magnets.
- Permanent magnets
- Electromagnetism
- Movement of electrical charges

COMPETENCY GOAL 5: The learner will build an understanding of the structure and properties of matter.

Objectives

5.01 Develop an understanding of how scientific processes have led to the current atomic theory.
- Dalton’s atomic theory.
- J.J. Thomson’s model of the atom.
- Rutherford’s gold foil experiment
- Bohr’s planetary model.
- Electron cloud model.

5.02 Examine the nature of atomic structure:
- Protons.
- Neutrons.
- Electrons.
- Atomic mass.
- Atomic number.
- Isotopes.

5.03 Identify substances through the investigation of physical properties:
- Density.
- Melting point.
- Boiling point.

COMPETENCY GOAL 6: The learner will build an understanding of regularities in chemistry.

Objectives

6.01 Analyze the periodic trends in the physical and chemical properties of elements.
- Groups (families).
- Periods.

6.02 Investigate and analyze the formation and nomenclature of simple inorganic compounds.
- Ionic bonds (including oxidation numbers).
- Covalent bonds.
- Metallic bonds.

6.03 Identify the reactants and products of chemical reactions and balance simple equations of various types:
- Single replacement.
- Double replacement.
- Decomposition.
- Synthesis.

6.04 Measure and analyze the indicators of chemical change including:
- Development of a gas.
- Formation of a precipitate.
- Release/absorption of energy (heat or light).

6.05 Investigate and analyze the properties and composition of solutions:
- Solubility curves.
- Concentration.
- Polarity.
- pH scale.
- Electrical conductivity.

6.06 Describe and explain radioactivity and its practical application as an alternative energy source:
- Alpha, beta, and gamma decay.
- Fission.
- Fusion.
- Nuclear waste.

PHYSICS

Goals

Physics, the most fundamental of the natural sciences, is quantitative in nature and uses the language of mathematics to describe natural phenomena. Inquiry is applied to the study of matter and energy and their interaction. The following topics are "uncovered" in this curriculum:

- Conservation of mass and energy.
- Conservation of momentum.
- Waves.
- Interactions of matter and energy.

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Unifying Concepts

The following unifying concepts should unite the study of various physics topics across grade levels.

- Systems, Order and Organization.
- Evidence, Models, and Explanation.
- Constancy, Change, and Measurement.
- Evolution and Equilibrium.
- Form and Function.

Nature of Science

This strand includes the following sections: Science as a Human Endeavor, Historical Perspectives, and the Nature of Scientific Knowledge. These sections are designed to help students understand the human dimensions of science, the nature of scientific thought, and the role of science in society. Physics is rich in examples of science as a human endeavor, its historical perspectives, and the development of scientific understanding.

Science as a Human Endeavor

Intellectual honesty and an ethical tradition are hallmarks of the practice of science. The practice is rooted in accurate data reporting, peer review, and making findings public. This aspect of the nature of science can be implemented by designing instruction that encourages students to work collaboratively in groups to design investigations, formulate hypotheses, collect data, reach conclusions, and present their findings to their classmates.

The content studied in physics provides an opportunity to present science as the basis for engineering, electronics, computer science, astronomy and the technical trades. The diversity of physics content allows for looking at science as a vocation. Scientist, artist, and technician are just a few of the many careers in which a physics background is necessary.

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behavior of objects accelerating at velocities approaching the speed of light.

- Laws are fundamentally different from theories. They are universal generalizations based on observations of the natural world, such as the nature of gravity, the relationship of forces and motion, and the nature of planetary movement.
- Scientists, in their quest for the best explanations of natural phenomena, employ rigorous methods. Scientific explanations must adhere to the rules of evidence, make predictions, be logical, and be consistent with observations and conclusions. "Explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific." (National Science Education Standards, 1996, p 201)

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Inquiry should be the central theme in physics. It is an integral part of the learning experience and may be used in both traditional class problems and laboratory work. The essence of the inquiry process is to ask questions that stimulate students to think critically and to formulate their own questions. Observing, classifying, using numbers, plotting graphs, measuring, inferring, predicting, formulating models, interpreting data, hypothesizing, and experimenting all help students to build knowledge and communicate what they have learned. Inquiry is the application of creative thinking to new and unfamiliar situations. Students should learn to design solutions to problems that interest them. This may be accomplished in a variety of ways, but situations that present a discrepant event or ones that challenge students' intuitions have been successful.

Classical experiments such as measuring inertia and the speed of falling bodies need not be excluded. Rather, they should be a prelude to open-ended investigations in which students have the chance to pose questions, design experiments, record and analyze data, and communicate their findings. For example, after measuring the relationships among force, mass, and acceleration of falling bodies, students might investigate the phenomenon of "weightlessness."

Although original student research is often relegated to a yearly science fair project, continuing student involvement in research contributes immensely to their understanding of the process of science and to their problem-solving abilities. Physics provides much potential for inquiries. "Would it be easier to identify the location of a sound source in water or in air?" Why?" "Would the passengers in a head-on collision between two automobiles be safer if the cars bounced off of each other or if they stuck together?" "Why?" The processes of inquiry, experimental design, investigation, and analysis are as important as finding the correct answer. Students will master much more than facts and acquisition of manipulative skills; they will learn to be critical thinkers.

A solid conceptual base of scientific principles, as well as knowledge of science safety, is necessary for inquiry. Students should be given a supportive learning environment based on how scientists and engineers work. Adherence to all science safety criteria and guidelines for classroom, field, and laboratory experiences is imperative. Contact the Science Section at DPI for information and professional development opportunities regarding North Carolina specific Science Safety laws, codes, and standards. The Science Section is spearheading a statewide initiative entitled *NC-The Total Science Safety System*.

Science and Technology

It is impossible to learn science without developing some appreciation of technology. Therefore, this strand has a dual purpose: (a) developing students' knowledge and skills in technological design, and (b) enhancing their understanding of science and technology.

The methods of scientific inquiry and technological design share many common elements - objectivity, clear definition of the problem, identification of goals, careful collection of observations and data, data analysis, replication of results, and peer review. Technological design differs from inquiry in that it must operate within the limitations of materials, scientific laws, economics, and the demands of society. Together, science and technology present many solutions to problems of survival and enhance the quality of life.

Technological design is important to building understanding in physics. Telescopes, lasers, transistors, graphing calculators, personal computers, and photo gates, for example, have changed our lives, increased our knowledge of physics, and improved our understanding of the universe.

Science in Personal and Social Perspectives

This strand is designed to aid students in making rational decisions in the use of scientific and technological understanding. "Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges." (NSES, p. 199). The *NSES* emphasizes that students should understand the appropriateness and value of basic questions 'What can happen?' - 'What are the odds?' and 'How do scientists and engineers know what will happen?'" (NSES, p. 199).

Students should understand the causes and extent of science-related challenges. They should become familiar with the advances that proper application of scientific principles and products have brought to environmental enhancement, better energy use, reduced vehicle emissions, and improved human health.

PHYSICS - Grades 9-12

Physics, the most fundamental of the natural sciences, is quantitative in nature and uses the language of mathematics to describe natural phenomena. Inquiry is applied to the study of matter and energy and their interaction. Learners will study natural and technological systems. The program strands and unifying concepts provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Identify questions and problems that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

1.04 Apply safety procedures in the laboratory and in field studies:
- recognize and avoid potential hazards.
- safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of:
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will build an understanding of linear motion.

Objectives

2.01 Analyze velocity as a rate of change of position:
- Average velocity.
- Instantaneous velocity.

2.02 Compare and contrast as scalar and vector quantities:
- Speed and velocity.
- Distance and displacement.

2.03 Analyze acceleration as rate of change in velocity.

2.04 Using graphical and mathematical tools, design and conduct investigations of linear motion and the relationships among:
- Position.
- Average velocity.
- Instantaneous velocity
- Acceleration.
- Time.

COMPETENCY GOAL 3: The learner will build an understanding of two-dimensional motion including circular motion.

Objectives

3.01 Analyze and evaluate projectile motion in a defined frame of reference.

3.02 Design and conduct investigations of two-dimensional motion of objects.

3.03 Analyze and evaluate independence of the vector components of projectile motion.

3.04 Evaluate, measure, and analyze circular motion.

3.05 Analyze and evaluate the nature of centripetal forces.

3.06 Investigate, evaluate and analyze the relationship among:

- Centripetal force.
- Centripetal acceleration.
- Mass.
- Velocity.
- Radius.

COMPETENCY GOAL 4: The learner will develop an understanding of forces and Newton's Laws of Motion.

Objectives

4.01 Determine that an object will continue in its state of motion unless acted upon by a net outside force (Newton's First Law of Motion, The Law of Inertia).

4.02 Assess, measure and calculate the conditions required to maintain a body in a state of static equilibrium.

4.03 Assess, measure, and calculate the relationship among the force acting on a body, the mass of the body, and the nature of the acceleration produced (Newton's Second Law of Motion).

4.04 Analyze and mathematically describe forces as interactions between bodies (Newton's Third Law of Motion).

4.05 Assess the independence of the vector components of forces.

4.06 Investigate, measure, and analyze the nature and magnitude of frictional forces.

4.07 Assess and calculate the nature and magnitude of gravitational forces (Newton's Law of Universal Gravitation).

COMPETENCY GOAL 5: The learner will build an understanding of impulse and momentum.

Objectives

5.01 Assess the vector nature of momentum and its relation to the mass and velocity of an object.

5.02 Compare and contrast impulse and momentum.

5.03 Analyze the factors required to produce a change in momentum.

5.04 Analyze one-dimensional interactions between objects and recognize that the total momentum is conserved in both collision and recoil situations.

5.05 Assess real world applications of the impulse and momentum, including but not limited to, sports and transportation.

COMPETENCY GOAL 6: The learner will develop an understanding of energy as the ability to cause change.

Objectives

6.01 Investigate and analyze energy storage and transfer mechanisms:
- Gravitational potential energy.
- Elastic potential energy.
- Thermal energy.
- Kinetic energy.

6.02 Analyze, evaluate, and apply the principle of conservation of energy.

6.03 Analyze, evaluate, and measure the transfer of energy by a force.
- Work.
- Power.

6.04 Design and conduct investigations of:
- Mechanical energy.
- Power.

COMPETENCY GOAL 7: The learner will develop an understanding of wave motion and the wave nature of sound and light.

7.01 Analyze, investigate, and evaluate the relationship among the characteristics of waves:
- Wavelength.
- Frequency.
- Period.
- Amplitude.

7.02 Describe the behavior of waves in various media.

7.03 Analyze the behavior of waves at boundaries between media:
- Reflection, including the Law of Reflection.
- Refraction, including Snell's Law.

7.04 Analyze the relationship between the phenomena of interference and the principle of superposition.

7.05 Analyze the frequency and wavelength of sound produced by a moving source (the Doppler Effect).

COMPETENCY GOAL 8: The learner will build an understanding of static electricity and direct current electrical circuits.

Objectives

8.01 Analyze the nature of electrical charges.

- Investigate the electrical charging of objects due to transfer of charge.
- Investigate the conservation of electric charge.
- Analyze the relationship among force, charge and distance summarized in Coulomb's law.

8.02 Analyze and measure the relationship among potential difference, current, and resistance in a direct current circuit.

8.03 Analyze and measure the relationship among current, voltage, and resistance in circuits.

- Series.
- Parallel.
- Series-parallel combinations.

8.04 Analyze and measure the nature of power in an electrical circuit.

Advanced Placement (AP®) Science Courses

The AP® science courses are intended to provide a rigorous college level introduction to the sciences for high school students. The College Board recommends that teachers complete an AP® Institute or workshop before teaching an AP® course. Additional information on teacher professional development, recommended texts, the courses, and the AP® exams is available to educators at the College Board website http://apcentral.collegeboard.com. AP® teachers can also join a discussion group with other AP® teachers in their discipline by signing up on AP® Central. Students can visit www.collegeboard.com/apstudents for additional information.

With the permission of the College Board, the North Carolina Department of Public Instruction has adapted the College Board materials to provide course outlines in the SCS format. These course outlines are in no way intended to replace the extensive materials provided by the College Board. The AP®course description books for each subject which include the topics and recommended laboratory experiences are revised frequently. It is the responsibility of AP® teachers to obtain and follow the current course description for their course.

AP® Biology

AP®Biology is intended to provide a rigorous introductory college level biology course with laboratory activities for high school students. The following course materials are in no way intended to replace the extensive materials provided by the College Board. The AP®course outline and recommended laboratory experiences are revised periodically by the College Board. Each teacher of this course should be sure to have the most up-to-date AP® Biology course description book and materials from the College Board. These materials are available at the AP® Central website http://apcentral.collegeboard.com.

The AP® Biology course is equivalent to a two-semester introductory college biology course. This course covers in greater scope and scale the concepts, knowledge, and skills introduced in a first level high school biology program. Greater amounts of time and effort are expected on the part of the student.

The major themes for this course are expected to permeate the entire course. The purpose of these themes is to tie the curriculum together and assist students in assimilating the materials into an expandable understanding. The eight major themes are:

1. Science as a Process
2. Evolution
3. Energy Transfer
4. Continuity and Change
5. Relationship of Structure to Function
6. Regulation
7. Interdependence in Nature
8. Science, Technology, and Society

The College Board website will provide additional detail and support as well as a list of recommended laboratories that are an integral part of the AP® Biology course.

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Identify questions and create hypotheses that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer biological questions.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.
-

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations from an informed scientifically literate viewpoint including considerations of:
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Consideration of alternative interpretations of the data.

Competency Goal 2: The learner will develop an understanding of cells as the structural and functional units of life.

Objectives

2.01 Compare and contrast prokaryotic and eukaryotic cells.
- Relationship to each other.
- Evolution.

2.02 Analyze cellular membranes.
- Structure and function.
- Variations.
- Investigate mechanisms of transport.
- Recommended laboratory - *Diffusion and Osmosis*

2.03 Examine sub cellular organization.
- Describe the structure of cell organelles.
- Relate structure to function.
- Identify factors that limit cell size.
- Interpret function of organelles in cellular processes.

2.04 Analyze the continuity and diversity provided by the cell cycle.
- Mechanisms of mitosis and cytokinesis.
- Regulation.
- Possible aberrations.

2.05 Examine past and present research on cells, their structure and function.

Competency Goal 3: The learner will develop an understanding that cellular processes are based on physical and chemical changes.

Objectives

3.01 Analyze the chemical and physical properties of water.

3.02 Examine the structure and function of organic molecules.
- Role of carbon in molecular diversity.
- Synthesis and breakdown of macromolecules.
- Including:
    - Carbohydrates.
    - Lipids.
    - Proteins.
    - Nucleic Acids.

3.03 Analyze free energy changes in biochemical processes.
- Relate to laws of thermodynamics.
- Examine process participants.

3.04 Describe the structure and function of enzymes.
- Regulation by enzymes of chemical reactions.
- Dependence of specificity to structure.
- Regulation of enzymes.
- Recommended laboratory - *Enzyme Catalysts*

3.05 Analyze bioenergetic reactions.
- Compare and contrast:
  - Fermentation.
  - Cellular respiration.
  - Photosynthesis.
- Examine the purpose, interactions, and adaptations of bioenergetic reactions.
- Recommended laboratories - *Plant Pigments and Photosynthesis, Cell Respiration*

3.06 Examine past and present research on biochemistry and cellular processes.

Competency Goal 4: The learner will develop an understanding of the basis of heredity and the role of molecular genetics.

Objectives

4.01 Analyze meiosis and gametogenesis.
- Analyze heredity.
- Compare and contrast gametogenesis in plants and animals.
- Recommended laboratory - *Mitosis and Meiosis*

4.02 Assess the organization of eukaryotic chromosomes.
- Assess contribution of continuity.
- Assess contribution of variability.
- Recommended laboratory - *Genetics of Organisms*

4.03 Interpret and use the principal patterns of inheritance.

4.04 Compare and contrast the structure and function of RNA and DNA.
- Investigate replication and the complimentary nature of DNA.
- Examine transcription.
- Examine translation.
- Explore the role of amino acids.
- Analyze energy requirements.
- Compare structure as it relates to function.
- Analyze genomes in prokaryotes and eukaryotes.

4.05 Assess gene regulation and the mechanisms by which it occurs.

4.06 Analyze the ways in which mutations can occur and the possibility of genetic variation.

4.07 Investigate viruses.
- Examine structure.
- Analyze steps of replication.
- Assess ability to transfer genetic information between cells.
- Explore current applications and research.

4.08 Examine current nucleic acid technology and its applications.
- Analyze recombinant technology.
- Examine practical applications in medicine, forensics, agriculture, and environmental issues.
- Assess legal and ethical issues that may arise.
- Recommended Laboratory – *Molecular Biology*

4.09 Examine past and present research on heredity and molecular genetics.
- Explore the work of Mendel.
- Explore the work of Watson and Crick.

Competency Goal 5: The learner will develop an understanding of biological evolution.

Objectives

5.01 Examine the evidence that supports an evolutionary view of life.

5.02 Recognize the implications of chemical evolution and its impact on the origin of life.

5.03 Analyze current models for the early evolution of life.
- Biological macromolecules.
- Prokaryotic cells.
- Eukaryotic cells.

5.04 Analyze the mechanisms of evolution, their role, results and implications.
- Identification of patterns and the responsible mechanisms.
- Analyze heredity and its link to natural selection.
- Examine speciation.
- Examine macroevolution.
- Recommended laboratory - *Population Genetics and Evolution*

5.05 Investigate the contributions of early researchers, (e.g. Pasteur and Darwin) and their impact on the current view of evolutionary biology.

Competency Goal 6: The learner will develop an understanding of the unity and diversity of life.

Objectives

6.01 Analyze evolutionary patterns.
- Examine DNA analysis.
- Examine biochemical analysis.
- Examine morphological research.

6.02 Survey the diversity of life.
- Use keys to identify organisms.
- Examine representative organisms.

6.03 Analyze and apply current phylogenetic classification including:
- Domains.
- Kingdoms.
- Major Phyla and divisions of animals and plants.

6.04 Analyze evolutionary relationships.
- Investigate evidence.

- Explore research methods.
- Analyze use of research.

6.05 Examine the structure and function of plants and animals.
- Analyze reproduction, growth, and development.
    - Patterns.
    - Adaptations (e.g. alternation of generations).
    - Regulation as by hormones.
- Recommended laboratory - *Transpiration*
- Analyze structural, physiological, and behavioral adaptations.
    - Cell level.
    - Tissue level.
    - Organ level.
    - Interactions between levels of organization.
- Recommended laboratories - *Physiology of the Circulatory System, Animal Behavior*
- Identify responses to the environment.

6.06 Examine past and present research on the unity and diversity of life.

Competency Goal 7: The learner will develop an understanding of basic ecological principles.

Objectives

7.01 Analyze population dynamics.
- Examine models to describe growth.
- Explore affects of abiotic and biotic factors.
- Analyze the impact of population changes.

7.02 Examine the actions and interactions of communities and ecosystems.
- Analyze energy flow.
- Examine trophic structure.
- Investigate water and element cycling.
- Assess affects of abiotic and biotic factors.
- Analyze relationships with in communities and ecosystems.
- Recommended laboratory - *Dissolved Oxygen and Aquatic Primary Production*

7.03 Assess current global issues.
- Analyze affects of human population.
- Analyze affects of technology.
- Examine causes.
- Assess consequences.

7.04 Examine past and present research on ecological principles.

AP® Chemistry

AP® Chemistry is the equivalent of an introductory college-level chemistry course. AP® Chemistry has both the content and the laboratory components of typical college-level chemistry courses. The College Board recommends that students who take AP® Chemistry should have successfully completed a first-year course in chemistry and have the math skills attained in Algebra I and II. AP® Chemistry builds on the skills and knowledge attained in a standard high school course and provides the student with an opportunity to develop a deeper understanding of chemistry and the ability to think critically and to solve problems.

The following course materials are in no way intended to replace the extensive materials provided by the College Board. The AP® course outline and recommended laboratory experiences are revised periodically by the College Board. The teacher of this course should be sure to have the current AP® Chemistry course description book and materials from the College Board. These materials are available at the AP Central website http://apcentral.collegeboard.com.

Learners will study natural and technological systems. The strands and unifying concepts provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

-Systems, Order and Organization
-Evidence, Models, and Explanation
-Constancy, Change, and Measurement
-Evolution and Equilibrium
-Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

Competency Goal 1: The learner will develop abilities necessary to do and understand scientific inquiry.

1.01 Design, conduct and analyze investigations to answer questions related to chemistry.
- Identify questions and suggest hypotheses.
- Identify variables.
- Use a control when appropriate.
- Select and use appropriate measurement tools.
- Collect and organize data in tables, charts and graphs.
- Analyze and interpret data.
- Explain observations.
- Make inferences and predictions.
- Explain the relationship between evidence and explanation.

- Identify how scientists share findings.

1.02 Analyze reports of scientific investigations.
- Appropriate sample.
- Adequacy of experimental controls.
- Replication of findings.
- Consideration of alternative interpretations of the data.

1.03 Analyze experimental designs with regard to safety.
- Identify potential safety hazards given a scenario.
- Differentiate between safe and unsafe procedures.
- Use information from the MSDS (Material Safety Data Sheets) to assess chemical hazards.

Competency Goal 2: The learner will develop an understanding of the composition and properties of matter.

2.01 Analyze the structure of matter at the atomic level
- Evidence for the atomic theory.
- Atomic masses; determination by chemical and physical means.
- Atomic number and mass number; isotopes.
- Electron energy levels: atomic spectra, quantum numbers, atomic orbitals.
- Periodic relationships including, for example, atomic radii, ionization energies, electron affinities, oxidation states.

2.02 Examine the types of chemical bonds and the nature of each
- Types: ionic, covalent, metallic, hydrogen bonding, van der Waals (including London dispersion forces).
- Relationships to states, structure, and properties of matter.
- Polarity of bonds, electronegativities.

2.03 Analyze conceptual models of bonding and molecular shape and the relation to chemical and physical properties of matter.
- Lewis structures.
- VSEPR.
- Valence bond: hybridization of orbitals, resonance, sigma and pi bonds.
- Geometry of molecules and ions, structural isomerism of simple organic. molecules and coordination complexes; dipole moments of molecules; relation of properties to structure.

2.04. Assess the impact of nuclear chemistry
- Nuclear decay equations.
- Half-life and radioactivity.
- Chemical applications.

Competency Goal 3: The learner will build an understanding of the states of matter and the connection to chemical and physical properties.

3.01 Examine the relationships between pressure, volume and temperature of ideal gases
- Laws of ideal gases: Boyle's, Charles'.
- The ideal gas equation.
- Partial pressures and Dalton's Law.

3.02. Analyze kinetic-molecular theory
- Interpretation of ideal gas laws on the basis of this theory.
- Avogadro's hypothesis and the mole concept.
- Dependence of kinetic energy of molecules on temperature.
- Deviations from ideal gas laws.

3.03. Assess the nature of liquids and solids
- Liquids and solids from the kinetic-molecular viewpoint.
- Phase diagrams of one-component systems.
- Changes of state, including critical points and triple points.
- Structure of solids; lattice energies.

3.04 Examine the nature of solutions
- Types of solutions and factors affecting solubility.
- Methods of expressing concentration (The use of normalities is not tested.).
- Raoult's law and colligative properties (nonvolatile solutes); osmosis.
- Non-ideal behavior (qualitative aspects).

Competency Goal 4: The learner will develop an understanding of chemical reactions.

4.01 Analyze the various types of common chemical reactions
- Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis;
- Coordination complexes; amphoterism.
- Precipitation reactions.
- Oxidation-reduction reactions.
  - Oxidation number.
  - The role of the electron in oxidation-reduction.
  - Electrochemistry: electrolytic and galvanic cells; Faraday's laws; standard half-cell potentials; Nernst equation; prediction of the direction redox reactions.

4.02 Apply the principles of stoichiometry
- Ionic and molecular species present in chemical systems: net ionic equations.
- Balancing of equations including those for redox reactions.
- Mass and volume relations with emphasis on the mole concept, including empirical formulas and limiting reactants.

4.03 Analyze systems in dynamic equilibrium
- Concept of dynamic equilibrium, both physical and chemical; Le Chatelier's principle; equilibrium constants.
- Quantitative treatment for gaseous reactions using K_p and K_c.
- Quantitative treatment for reactions in solution K_c.
- Quantitative treatment of for acids and bases; using K_a and K_b, pK_a and pK_b and pH.
- Quantitative treatment for precipitation reactions and the dissolution of slightly soluble compounds using the solubility product constant, K_{sp}.
- Common ion effect; buffers; hydrolysis.

4.04 Analyze chemical kinetics
- Concept of rate of reaction.
- Use of differential rate laws to determine order of reaction and rate constant from experimental data.

- Effect of temperature change on rates.
- Energy of activation; the role of catalysts.
- The relationship between the rate-determining step and a mechanism.

4.05 Analyze chemical thermodynamics

- State functions.
- First law: change in enthalpy; heat of formation; heat of reaction; Hess's law; heats of vaporization and fusion; calorimetry.
- Second law: entropy; free energy of formation; free energy of reaction; dependence of change in free energy on enthalpy and entropy changes.
- Relationship of change in free energy to equilibrium constants and electrode potentials.

Competency Goal 5: The learner will build a knowledge of descriptive chemistry

5.01 Examine chemical reactivity and predict the products of chemical reactions.

5.02 Analyze the relationships in the periodic table: horizontal, vertical, and diagonal with examples from alkali metals, alkaline earth metals, halogens, and the first series of transition elements.

5.03. Explore organic chemistry on an introductory level

- Hydrocarbons and functional groups (structure, nomenclature, chemical properties).
- Physical and chemical properties of simple organic compounds should also be included as exemplary material for the study of other areas such as bonding, equilibria involving weak acids, kinetics, colligative properties, and stoichiometric determinations of empirical and molecular formulas.

AP® Environmental Science

AP® Environmental Science is intended to provide a rigorous introductory college Environmental Science course with laboratory activities for high school students. The following course materials are in no way intended to replace the extensive materials provided by the College Board. The AP® course outline and recommended laboratory experiences are revised periodically by the College Board. The teacher of this course should be sure to have the most current AP® Environmental Science course description book materials from the College Board. These materials are available at the AP Central website http://apcentral.collegeboard.com.
The AP® Environmental Science course is equivalent to a one semester introductory college Environmental Science course.

Learners will study natural and technological systems. The strands and unifying concepts provide a context for teaching content and process skill goals. All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Identify questions and problems that can be answered through scientific investigations

1.02 Design and conduct scientific investigations to answer questions about the world.
- Create testable hypotheses.
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Observe and measure real phenomena.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions from data and observations.
- Explain the relationship between evidence and explanation.
- Communicate results, including suggested ways to improve experiments and proposed questions for further study.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulation materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations of phenomena from an informed scientifically literate viewpoints including considerations of:
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will build an understanding of the interdependence of Earth's systems.

Objectives

2.01 Analyze the flow of energy.
- Forms and quality of energy.
- Laws of Thermodynamics.
- Energy units and measurements.
- Sources and sinks, conversions.

2.02 Investigate the cycling of matter.
- Water.
- Carbon.
- Nitrogen.
- Phosphorus.
- Sulfur.

2.03 Investigate the solid Earth.
- Earth history and the geologic time scale.
- Influences of plate tectonics on evolution and biodiversity.
- Volcanism.
- The rock cycle.
- Soil formation.

2.04 Investigate the atmosphere.
- Atmospheric history: origin and evolution.
- Composition.
- Structure.
- Atmospheric dynamics: weather and climate.

2.05 Investigate the biosphere.
- Organisms: adaptations to their environment.
- Populations and communities: exponential growth and carrying capacity.
- Ecosystems and change: biomass, energy transfer, succession.
- Evolution of life: natural selection, extinction.
- Biomes: global distribution

COMPETENCY GOAL 3: The learner will build an understanding of human population dynamics.

3.01 Analyze human population history and global distribution.
- Demographics.
- Age structure diagrams.
- Survivorship curves.
- Patterns of resource distribution.

3.02 Investigate local, regional and global carrying capacities.
- Limiting factors.
- Density-dependent and density-independent factors.

3.03 Analyze cultural and economic influences on population
- Pronatalist factors.
- Antinatalist factors.
- Demographic transition.

COMPETENCY GOAL 4: The learner will build an understanding of the distribution, ownership, use and degradation of renewable and nonrenewable resources.

4.01 Analyze sources and uses of freshwater and oceans.
- Renewal rates.
- Agricultural, industrial and domestic water uses.
- Increasing water supplies: Dams and desalination.
- Fisheries and aquaculture.
- Water management and conservation.

4.02 Analyze local, regional and global mineral resources.
- Mining types.
- Processing and environmental effects.
- Mining Laws.

4.03 Analyze local, regional and global soil aspects.
- Soil composition and profiles.
- Soil characteristics.
- Soil types.
- Erosion and conservation .

4.04 Analyze biological resources.
- Benefits of biodiversity.
- Threats to biodiversity.
- Endangered species management.
- Nutrition and food supplies.
- Green revolution.

4.05 Analyze and compare conventional and alternative energy sources.
- Coal.
- Natural gas.
- Oil.
- Nuclear power.
- Solar energy.
- Biomass.
- Energy from the Earth's forces: Wind, Water, Geothermal, Tidal.
- Energy conservation.

- Identify facility parts (Coal, Nuclear).
- Monthly/annual costs.

4.06 Analyze land types and uses.
- Residential and commercial, land use planning.
- Agricultural and forestry.
- Recreational and wilderness.
- Ecotourism, Parks and preserves.

COMPETENCY GOAL 5: The learner will build an understanding of air, water and soil quality.

5.01 Analyze the sources of major pollutants.
- EPA Criteria Pollutants.
- Indoor air pollutants.
- Thermal pollution.
- Pesticides.
- Acid deposition.
- Units and measurements.
- Point and nonpoint sources.

5.02 Investigate the effects of pollutants on:
- Aquatic systems (Eutrophication).
- Vegetation.
- Natural features, buildings and structures.
- Wildlife.

5.03 Analyze and investigate pollution reduction, remediation and control measures.
- Legislation.
- Historical examples and global case studies.
- Waste water treatment plant.

5.04 Analyze and investigate local, regional and global issues concerning solid waste.
- Types, sources and amounts.
- Disposal methods and environmental effects.
- Decreasing waste: Reduce, reuse, recycle.

5.05 Analyze impacts on human health.
- Infectious disease.
- Chemical agents.
- Radiation.
- Toxicology: LD50, acute and chronic effects.
- Risk assessment.

COMPETENCY GOAL 6: The learner will build an understanding of global changes and their consequences.

6.01 Investigate human effects and consequences on the atmosphere.
- Stratospheric Ozone: chemistry, historical aspects and legislation.
- Greenhouse gases and global warming.

6.02 Investigate effects and consequences on the oceans.
- Sea level changes.
- El Nino.
- Surface temperatures and currents.

6.03 Investigate effects and consequences on biota:
- Habitat fragmentation and destruction.
- Introduced species.
- Overharvesting.

COMPETENCY GOAL 7: The learner will build an understanding of environmental decision making.

7.01 Analyze economic forces affecting societies.
- Supply demand curves.
- Cost benefit analysis.
- Marginal, internal and external costs.
- Communal property resources, Tragedy of the Commons.
- Economic resource categories.

7.02 Analyze cultural and ethical considerations regarding the environment.
- Environmental worldviews.
- Indigenous peoples.
- Sustainable development.

7.03 Recognize significance of major environmental laws and regulations: regional, national and international.
- Clean Air Act.
- Clean Water Act.
- Comprehensive Environmental Response, Compensation and Liability Act.
- Convention on International Trade in Endangered Species.
- Endangered Species Act.
- Federal Insecticide, Fungicide and Rodenticide Control Act.
- Kyoto Protocol.
- Lacey Act.
- Mining Act.
- Montreal Protocol.
- National Environmental Policy Act.
- Resource Conservation and Recovery Act.
- Wilderness Act.

7.04 Develop an awareness of environmental options.
- Conservation.
- Preservation.
- Restoration.
- Remediation.
- Mitigation.

COMPETENCY GOAL 8: The learner will build an understanding of Earth in the Solar System and its position in the universe.

8.01 Analyze the formation of the solar system.

8.02 Analyze planetary motion and the physical laws that explain motion.
- Rotation.
- Revolution.
- Apparent diurnal motion of the sun and stars.

- Tilt of Earth's axis.
- Parallelism of the Earth's axis.

8.03 Evaluate astronomers' use of various instruments to extend their senses:
- Optical telescopes.
- Radio telescopes.
- Spectroscopes.
- Cameras.

8.04 Assess the current scientific theories of the origin of the universe.
8.05 Examine the sources of stellar energies.
8.06 Assess the spectra generated by stars and our sun as indicators of motion:
- Doppler effect.
- Red and blue shifts.

8.07 Evaluate Hubble's Law and the concept of the ever-expanding universe.
8.08 Evaluate the life cycle of stars in the Hertzsprung-Russell diagram (H-R Diagram).

AP® Physics

AP® Physics is offered as two separate courses: AP® Physics B and AP® Physics C. AP® Physics B includes topics in mechanics and thermal physics, waves and optics, and atomic and nuclear physics at a level appropriate for a college introductory course for majors in the natural sciences outside of the physical sciences and engineering. AP® Physics B is recommended as a second-year physics course for students interested in life, medical and/or applied science. Algebra and trigonometry are used to quantitatively study nature and describe phenomena. Inquiry is applied to the study of matter and energy and their interaction.

AP® Physics C includes mechanics, electricity and magnetism at a level appropriate for college majors in the physical sciences and engineering. Calculus is used to develop concepts. One part of the Physics C examination covers mechanics; the other part covers electricity and magnetism. Students are permitted to take either or both parts of this examination, and separate grades are reported for the two subject areas to provide greater flexibility in planning AP® courses and making advanced placement decisions. (apcentral.collegeboard.com)

The College Board recommends a high school physics course be taken as preparation for either Physics B or Physics C for most students.

AP® Physics B

AP® Physics B is intended to provide a rigorous introductory college level physics course with laboratory activities for high school students. The following course materials are in no way intended to replace the extensive materials provided by the College Board. The AP® course outline and recommended laboratory experiences are revised periodically by the College Board. The teacher of this course should have the most current copy of the AP® Physics B course description book and materials from the College Board. These materials are available at the AP Central website http://apcentral.collegeboard.com.

Inquiry is applied to the study of matter and energy and their interaction. Learners will study natural and technological systems. The program strands and unifying concepts provide a context for teaching content and process skill goals.

All goals should focus on the unifying concepts:

- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.01 Identify questions and problems that can be answered through scientific investigations.

1.02 Design and conduct scientific investigations to answer questions about the physical world.

- Create testable hypotheses
- Identify variables.
- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Observe and measure real phenomena
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Determine uncertainties in measurements.
- Communicate findings.

1.03 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions from data and observations.
- Explain the relationship between evidence and explanation.
- Communicate results, including suggested ways to improve experiments and proposed questions for further study.

1.04 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.

1.05 Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoints including considerations of:
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will build an understanding of Newtonian mechanics

2.01 Analyze and evaluate a particle using kinematics (movement in one, two, and circular dimensions).
- Motion in one dimensions.
- Relate position, velocity, and acceleration of a particle for motion.
- Motion in two dimensions.
- Addition and subtraction of displacement and velocity vectors
- Visual, graphical, mathematical expressions of the motion of a projectile in a uniform gravitational field.
- Relate a particles radius, speed, velocity, and acceleration in uniform circular motion.

2.02 Investigate, measure, and analyze Newton's laws of motion
- Static equilibrium (first law).
- Dynamics of a single particle (second law).
- Systems of two or more bodies (third law).
    - Velocity with constant force and average force.
    - Force diagram.
- Normal and frictional forces.
- Action and reaction forces an two or more bodies (third law).
- Tension.

2.03 Examine and calculate work, energy and power.
- Work and work-energy theorem.
- Conservative forces and potential energy.
- Conservation of energy.
- Power.

2.04 Analyze and evaluate systems of particles and linear momentum.
- Impulse and momentum.
- Conservation of linear momentum and collisions.

2.05 Evaluate and analyze circular motion and rotation.
- Uniform circular motion.
- Torque and rotational statics.

2.06 Investigate and analyze oscillations and gravitation.
- Simple harmonic motion (dynamics and energy relationships).
- Mass on a spring.
- Pendulum and other oscillations.
- Newton's law of gravity.
- Circular orbits of planets and satellites.

COMPETENCY GOAL 3: The learner will build an understanding of fluid mechanics and thermal physics.

3.01 Examine and evaluate fluid mechanics.
- Hydrostatic pressure.
- Buoyancy.
- Fluid flow continuity.
- Bernoulli's principle.

3.02 Evaluate and investigate temperature and heat.
- Mechanical equivalent of heat.
- Heat transfer and thermal expansion.

3.03 Examine and evaluate kinetic theory and thermodynamics.
- Ideal gases-kinetic model and ideal gas law.
- Laws of thermodynamics-first law (including processes on PV diagrams) and second law (including heat engines).

COMPETENCY GOAL 4: The learner will build an understanding of electricity and magnetism.

4.01 Study and analyze electrostatics.
- Charge, field, and potential.
- Coulomb's law and field and potential of point charges.
- Planar fields and potentials of other charge distributions.

4.02 Evaluate and analyze conductors, capacitors, and dielectrics.
- Electrostatics with conductors.
- Parallel plate capacitors.

4.03 Analyze and investigate electric circuits.
- Current, resistance, and power.
- Steady-state direct current circuits with batteries and resistors only.
- Steady-state capacitors in circuits.

4.04 Study and evaluate magnetostatics.
- Forces on moving charges in magnetic fields.
- Forces on current-carrying wires in magnetic fields.
- Fields of long current-carrying wires.

4.05 Measure and analyze electromagnetism.
- Electromagnetic induction (including Faraday's law and Lenz's law).

COMPETENCY GOAL 5: The learner will build an understanding of waves and optics.

5.01 Study and evaluate wave motion.
- Properties of traveling waves.
- Properties of standing waves.
- Doppler effect.
- Superposition.

5.02 Evaluate and analyze physical optics.
- Interference and diffraction.
- Dispersion of light and the electromagnetic spectrum.

5.03 Investigate and analyze geometric optics.
- Reflection and refraction.
- Mirrors.
- Lenses.

COMPETENCY GOAL 6: The learner will build an understanding of atomic and nuclear physics.

6.01 Analyze and evaluate atomic physics and quantum effects.
- Photons and the photoelectric effects.
- Atomic energy levels.
- Wave-particle duality.

6.02 Evaluate, measure, and analyze nuclear physics.
- Nuclear reactions (including conservation of mass number and charge).
- Mass-energy equivalence.

AP® Physics C

AP® Physics C is intended to provide a rigorous introductory college level Physics course with laboratory activities. AP® Physics C includes mechanics, electricity and magnetism at a level appropriate for college majors in the physical sciences and engineering. Calculus is used to develop concepts. One part of the Physics C examination covers mechanics; the other part covers electricity and magnetism. Students are permitted to take either or both parts of this examination, and separate grades are reported for the two subject areas to provide greater flexibility in planning AP® courses and making advanced placement decisions. (apcentral.collegeboard.com) The following course materials are in no way intended to replace the extensive materials provided by the College Board. The AP® course outline and recommended laboratory experiences are revised periodically by the College Board. The teacher of this course should have the most current copy of the AP® Physics C course description book and materials from the College Board. These materials are available at the AP Central website http://apcentral.collegeboard.com.

AP® Physics C is recommended as a second-year physics course for students interested in the physical science and/or engineering. Calculus is used to formulate physical principles of electricity and magnetism and solve problems. Inquiry is applied to the study of matter and energy and their interaction. Learners will study natural and technological systems. The program strands and unifying concepts provide a context for teaching content and process skill goals.

All goals should focus on the unifying concepts:
- Systems, Order and Organization
- Evidence, Models, and Explanation
- Constancy, Change, and Measurement
- Evolution and Equilibrium
- Form and Function

Strands: The strands are: Nature of Science, Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives. They provide the context for teaching of the content Goals and Objectives.

COMPETENCY GOAL 1: The learner will develop abilities necessary to do and understand scientific inquiry.

Objectives

1.06 Identify questions and problems that can be answered through scientific investigations.

1.07 Design and conduct scientific investigations to answer questions about the physical world.
- Create testable hypotheses.
- Identify variables.

- Use a control or comparison group when appropriate.
- Select and use appropriate measurement tools.
- Observe and measure real phenomena.
- Collect and record data.
- Organize data into charts and graphs.
- Analyze and interpret data.
- Determine uncertainties in measurements.
- Communicate findings.

1.08 Formulate and revise scientific explanations and models using logic and evidence to:
- Explain observations.
- Make inferences and predictions from data and observations.
- Explain the relationship between evidence and explanation.
- Communicate results, including suggested ways to improve experiments and proposed questions for further study.

1.09 Apply safety procedures in the laboratory and in field studies:
- Recognize and avoid potential hazards.
- Safely manipulate materials and equipment needed for scientific investigations.
    1. Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoints including considerations of:
- Adequacy of experimental controls.
- Replication of findings.
- Alternative interpretations of the data.

COMPETENCY GOAL 2: The learner will build an understanding of electrostatics.

2.01 Analyze and evaluate electric field.
- Calculate force, net force and torque on a charge or collection of charges in a specific field.
- Calculate and sketch equipotentials for a configuration.
- Use integration to determine electric potential.
- Utilize the conservation of electric field to solve problems.

2.02 Calculate and analyze Coulomb's law, field, and potential of point charges.
- Define magnitude and direction of a force and electric field on a charge.
- Calculate electric potential near one or more charges.
- Compute the force and electric field between charges.
- Determine the work necessary to move charges and potential energy of the system.

2.03 Evaluate and analyze fields and potentials of other charge distributions.
- Using the principle of superposition and integration, calculate:
    - Electric field for a wire and ring.
    - Electric potential for a disk.
- Determine the electric field of
    - Charged plates.
    - Uniformly charged wire.
    - Thin cylindrical shell.

- Determine the mathematical expression for various situation of electric potential.

2.04 State and apply Gauss's law.
- Determine the flux of electric field through an arbitrary surface.
- Use the integral form of Gauss's Law to determine electric flux and charge.
- Use Gauss's Law to find charge density on a surface.
- Graph electric field to find maxima and minima.

COMPETENCY GOAL 3: The learner will build an understanding of conductors, capacitors, and dielectrics.

3.01 Examine and analyze electrostatics with conductors.
- Describe and sketch the features of electric fields in and outside of a conductor.
- Describe the charge density on a conductor.
- Explain charging by induction and how charges are brought near a conductor.
- Clarify qualitatively the electric field region.

3.02 Identify and evaluate capacitors and dielectric.
- Define capacitance with stored charge and voltage.
- Recognize energy storage in relation to voltage, charge, and energy.
- Relate voltage, charge, and stored energy in a capacitor.
- Analyze capacitance and energy of a parallel plate.
- Define the electric field and capacitance in spherical and cylindrical objects.
- Explain how a dielectric affects the capacitance field strength and voltage.

COMPETENCY GOAL 4: The learner will build an understanding of electric circuits.

4.01 Measure and analyze the current, resistance, and power in electric circuits.
- Relate current and voltage for a resistor.
- Qualitatively describe what happens in terms of electric field strength, current density, and drift electron velocity in a conductor.
- Explain and calculate how cross-sectional area, length, and material affect the resistance of a resistor.
- Explain the rate of how heat is dissipated.

4.02 Examine and analyze steady-state direct current circuits with batteries and resistors.
- Define and relate current, resistance, and voltage.
- Identify series and parallel wiring in a circuit.
- Determine voltage, current, resistance, and power across series, parallel, and combination circuits.
- Draw a diagram of a series-parallel circuit using conventional symbols.
- Calculate terminal voltage and internal resistance for a known battery.
- Identify and calculate the current, voltage and resistance using Ohm's Law and Kirchoff's rules.
- Identify the properties and connections of an ammeter and voltmeter.

4.03 Evaluate and analyze capacitors in circuits.
- Explain the capacitance for capacitors in parallel and series circuits.
- Identify and examine energy storage in a capacitor.
- Explain the charge and voltage for capacitors in parallel and series circuits.

- Graph and mathematically express the discharging of a capacitor over time.
- Calculate and graph voltage and currents over time in a circuit.

COMPETENCY GOAL 5: The learner will build an understanding of magnetostatics.

5.01 Derive and analyze the force on a charge in a magnetic field.
- Calculate charge, force, velocity, and magnetic field.
- Explain why work cannot be performed by a magnetic field.
- Explain the motion of charged particle in a magnetic field.

5.02 Analyze the force on a current-carrying wire in magnetic fields.
- Relate the magnitude and direction of charge, velocity, magnetic field, and force on a moving charges and current-carrying wire in a magnetic field.
- Analyze the torque on a rectangular loop of wire in a magnetic field.

5.03 Examine the magnetic fields of long current-carrying wires.
- Analyze the magnetic fields of long current-carrying wires.
- Calculate the forces between long current-carrying wires.

5.04 Apply and use Biot-Savart and Ampere's law.
- Articulate and utilize Ampere's Law in the integral form to relate current to magnetic field strength.
- Analyze magnetic field for a long straight wire, solid cylinder, and hollow cylinder using law of superposition.

COMPETENCY GOAL 6: The learner will build an understanding of electromagnetism.

6.01 Evaluate and analyze electromagnetic induction using Faraday's law and Lenz's law.
- Calculate the flux of a uniform magnetic field.
- Calculate the magnetic flux of a nonuniform magnetic field using integration
- Identify the magnitude and direction of the induced emf and current in a uniform magnetic field for specific and general cases.
- Develop the skills necessary to solve basic problems with electromagnetic induction.

6.02 Formulate and examine inductance (including LR and LC circuits).
- Calculate the magnitude and emf for an inductor through which a specified changing current is flowing.
- Apply self-inductance for a long solenoid.
- Develop the skills necessary to solve basic circuits with resistors and inductors.

6.03 Explain Maxwell's equations in integral form and discuss their implications.

GLOSSARY

Attitude-tendency to respond positively or negatively to an idea, object, or person; influences ability to succeed in science; attitude towards science is influenced by how science is experienced

Classifying-the sorting or ordering of objects according to their properties or similarities and differences; based on observational relationships that exist between objects or events

Cognitive science-the study of how learning takes place

Communicating-the transmission of observable data; examples include spoken or written words, graphs, drawings, diagrams, maps, mathematical equations; skills such as asking questions, discussing, explaining, reporting, and outlining can aid in the development of communication skills

Conceptual understanding-includes the body of scientific knowledge that students draw upon when conducting a scientific investigation or engaging in scientific reasoning; involves a variety of information, including events from science instruction and experiences with the natural environment; scientific concepts, principles, laws, and theories that scientists use to explain and predict observations about the world

Controlling variables-managing the conditions or factors in an experiment necessary for the results of experimentation to be reliable

Curriculum-what students should understand and/or be able to do

Defining operationally-stating definitions in working terms

Evolving-change over time; may refer to biological changes, geological changes; and/or technological changes

Experimenting-testing a hypothesis under controlled conditions; basic to the total scientific process; uses all process skills

Hypothesis-forming a generalization / question based on observations; involves asking questions, making inferences and predictions; must be testable/tested to establish credibility

Inferring-using logic to draw conclusions from observations; suggests explanations, reasons, and/or causes for events; based on judgments; and may not always be valid

Inquiry-a set of interrelated processes by which students and scientists pose questions about the natural world and investigate phenomena; a critical component of a science program at all grade levels and in every domain of science; allows students to learn science in a way that reflects how science actually works (NSES, p. 214)

Instruction-methods used to structure learning opportunities to teach concepts

Interpreting data-integrated process skill; involves making predictions, inferences, and hypotheses from a set of data; revision of interpretations may be necessary when additional data are obtained

Investigate-Conducting a search or examination of evidence so as to understand a concept; inquire into systematically

Measuring-ordering of things by magnitude, such as area, length, volume, mass; processes to quantify observations; involves the use of instruments and the skills needed to use them effectively

Models-useful way of describing and explaining interrelationships of ideas; can be mental, physical, and/or verbal representation of an idea; represent what we know about an idea or concept; under constant change as new data are obtained

Nature of science-incorporates the historical development of science, habits of mind that characterize science, and methods of inquiry and problem solving

Nature of technology-encompasses the issues of design, application of science to real-world problems, and trade-offs or compromises that need to be considered for technological solutions

Observing-using one or more of the senses in perceiving properties or similarities and differences in objects and events; can be made directly with the senses or indirectly through the use of simple or complex instruments; influenced by the previous experience of the observer

Practical reasoning-probing students' ability to use and apply science understanding in new, real world applications

Predicting-suggesting what will occur in the future; based on observations, measurements, and inferences about relationships between or among observed variables; speculation of what will happen based on past experiences; accuracy of a prediction is affected by the accuracy of the observation; conjecture about how a particular system will behave, followed by observations to determine if the system did behave as expected within a specified range of situations

Scientific investigation-probes students' ability to use the tools of science, including both cognitive and laboratory tools; students acquire new information, plan appropriate tests, use a variety of scientific tools, and communicate the results of the investigations

Standards-criteria used to judge quality

Systems-complete, predictable cycles, structures, or processes occurring in natural phenomena; may also be an artificial construction created to represent or explain a natural occurrence; system boundaries and interrelationships of subsystems exist; input to and outputs from.

Technological design-abilities that include identifying appropriate problems, designing a solution or product, implementing a proposed design, evaluating completed solutions or products, communicating the process of design.

Themes-big ideas of science that transcend various scientific disciplines

Theory-an always tentative explanation of phenomena that we observe; never proven; representative of the most logical explanation based on currently available evidence; becomes stronger as more supporting evidence is gathered; provides a context for predictions.

Using numbers-quantifying variables, measurements, and/or comparisons; needed to manipulate measurements and to order and classify objects.

Using space/time relations-describing the spatial relationships of objects and their change with time; examples are motion, direction, spatial arrangement, symmetry, and shape.

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