2015 ALABAMA COURSE OF STUDY
SCIENCE

Thomas R. Bice, State Superintendent of Education · Alabama State Department of Education

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Alabama Course of Study: Science
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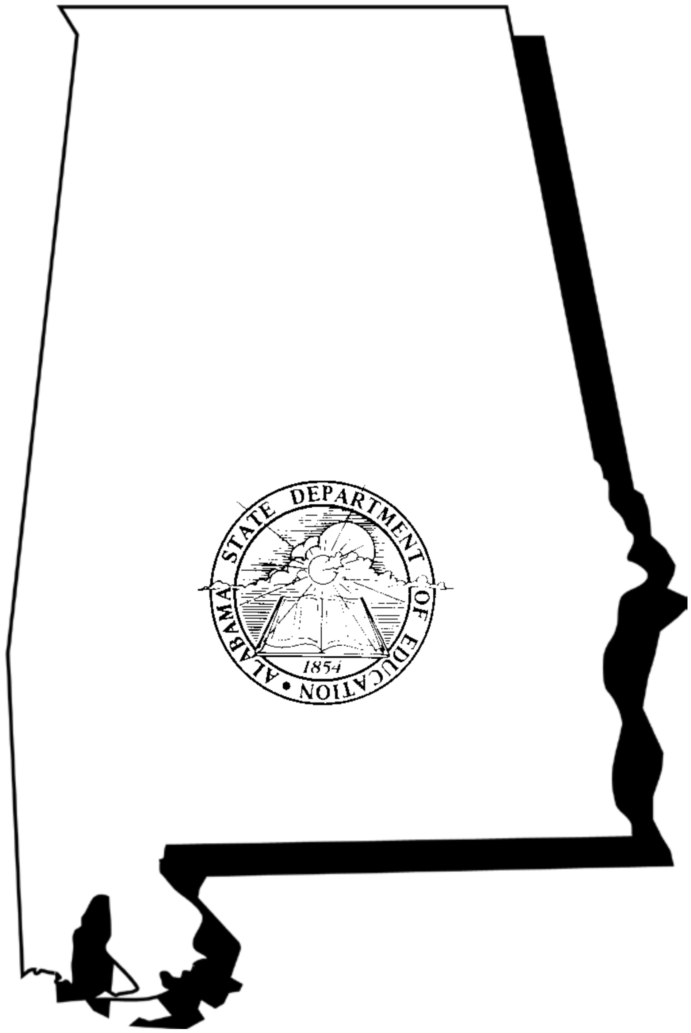

Thomas R. Bice
State Superintendent of Education
ALABAMA STATE DEPARTMENT OF EDUCATION

STATE SUPERINTENDENT OF EDUCATION'S MESSAGE

Dear Educator:

Our vision is "Every Child a Graduate—Every Graduate Prepared!" To be prepared for college and career in the twenty-first century, it is essential that students have access to a high-quality, solid science education. A great number of personal and societal issues require citizens to be scientifically literate and able to make informed decisions based on an understanding of science and technology. In addition, today's workforce depends on graduates who are prepared with necessary scientific and technological skills to address these issues. Our newly developed science standards affirm the importance of science literacy for all students.

The science standards reflect the interconnectedness of the nature of science as experienced in the real world. Science concepts build coherently in depth and rigor across Grades K-12 as students focus on deeper understanding and application of content. The standards in the course of study represent the minimum content required to prepare students for college, career, and citizenship.

The Alabama State Science Course of Study Committee and Task Force developed what I believe to be a superior set of standards that integrate interdisciplinary teaching and learning to guide local school systems in creating local curriculum for implementation in the schools. By using this new course of study as the foundation for what students should know and be able to do, students in the state of Alabama can meet the goal of graduating with the knowledge and skills that will enable them to succeed in post-high school education and the workforce.

Thomas R. Bice
State Superintendent of Education

Alabama Course of Study: Science

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PREFACE

The 2015 *Alabama Course of Study: Science* provides the framework for the K-12 science education program in Alabama's public schools. Content standards in this document are minimum and required (*Code of Alabama*, 1975, §16-35-4). They are fundamental and specific, but not exhaustive. When developing a local curriculum, each school system may include additional content standards that focus on local resources and needs. Implementation strategies and external resources may also be added to enhance student learning of science in Alabama schools.

The 2012-2015 Alabama State Science Course of Study Committee and Task Force reviewed the *Alabama Course of Study: Science* (Bulletin 2005, No. 20) and the 2012 National Research Council (NRC) publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, in developing the minimum required content that integrates scientific concepts and scientific and engineering practices. In addition, committee members read articles in professional journals and magazines, examined similar documents from other states, and studied national evaluations of state standards. Members reviewed suggestions from interested individuals and groups throughout Alabama, used each member's academic and experiential knowledge, and discussed each issue and standard among themselves. As a result, this document represents the scientific knowledge and practices necessary to provide graduates with scientific and engineering literacy for success in college, career, and citizenship.

The main goal of the Alabama course of study for science is to give all Alabama students a solid foundation in science and engineering. This course of study includes the most current scientific and engineering practices, cross-cutting concepts, and disciplinary core ideas our students need in order to become college and career ready. Providing the K-12 students of Alabama with a foundational understanding of scientific theories and laws will enable them to excel in the scientific discoveries of the future. Scientific theories are developed from observations and evidence to explain the nature of phenomena, to predict future outcomes, and to make inferences about the past. Scientific laws are supported by replicable experiments from within a controlled environment. Both theories and laws have equivalent utility and are open for revision in light of new evidence. The theory of evolution has a role in explaining unity and diversity of life on earth. This theory is substantiated with much direct and indirect evidence. Therefore, this course of study requires our students to understand the principles of the theory of evolution from the perspective of established scientific knowledge. The committee recognizes and appreciates the diverse views associated with the theory of evolution.

ACKNOWLEDGMENTS

This document was developed by the 2012-2015 Alabama State Science Course of Study Committee and Task Force composed of early childhood, intermediate school, middle school, high school, and college educators appointed by the Alabama State Board of Education and business and professional persons appointed by the Governor (*Code of Alabama*, 1975, §16-35-1). The Committee and Task Force began work in March 2012 and submitted the document to the Alabama State Board of Education for adoption at the August 2015 meeting.

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ALABAMA COURSE OF STUDY: SCIENCE
GENERAL INTRODUCTION

In response to our nation's declining competitiveness in the science, technology, engineering, and mathematics (STEM) fields, the National Research Council (NRC) published a research-based report on teaching and learning science in a 2012 document titled *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. This document proposes a new approach to K-12 science education through the integration of engineering design and engineering practices within the context of science content instruction. Supported by the NRC framework and our state's College- and Career-Readiness (CCR) Anchor Standards for Reading and for Writing (Appendix A), the goal of Alabama's K-12 science education standards is scientific and engineering literacy for all Alabama students. The 2015 *Alabama Course of Study: Science* defines the minimum required content that students should master to achieve this goal.

Since the present goal of Alabama's science education curriculum includes engineering literacy, it is important to define what is meant by the terms science, technology, and engineering. Science is the process of building a structured body of knowledge about the natural world delineated in the three traditional domains of physical, life, and earth and space sciences. Technology is defined as any modification of the natural world made to fulfill human needs or desires, thus expanding the interpretation of technology far beyond computers and electronic devices to include simple machines, steam engines, and musical instruments. Engineering, in a broad sense, involves engagement in a systematic practice of design in order to solve problems and generate products rising from human needs and wants. A major conceptual shift in K-12 science and engineering education includes a limited number of disciplinary core ideas in four domains that students explore with increasing rigor and depth over multiple years and the integration of such knowledge with the practices needed to engage in scientific inquiry and engineering design.

Scientific and engineering literacy enables students to become critical thinkers and informed decision makers in an increasingly technological society. While providing students with foundational knowledge of the core ideas of physical, life, and earth and space sciences, the 2015 *Alabama Course of Study: Science* will also help students develop competency in a specific set of engineering practices they can apply in everyday problem-solving situations. Developmentally appropriate engineering projects, beginning in kindergarten, provide a meaningful and relevant context in which students' knowledge and skills can be applied. Engineering projects should include all components of the engineering design process, including specific criteria for success and constraints on materials, time, and cost.

The structure of the Alabama course of study in science reflects the approach outlined by NRC's framework. The 2015 *Alabama Course of Study: Science* incorporates the three dimensions around which K-12 science and engineering education are built. These dimensions are scientific and engineering practices; crosscutting concepts that unify the study of science through their common application across all domains of science and engineering; and disciplinary core ideas in the physical, life, and earth and space sciences, and in engineering, technology, and applications of science.

Alabama's K-12 science program places emphasis on the importance of teaching science every day to every student in every grade. This document provides foundational knowledge and learning progressions that are coherent, vertically aligned, and increasingly rigorous in preparing scientifically literate citizens with the ability to evaluate the quality of science information and make informed personal choices, to gain an appreciation of science as a way of knowing about the world, and to be savvy science consumers. Effective implementation of the 2015 *Alabama Course of Study: Science* will help develop confident and capable graduates, the key to Alabama's economic productivity and our nation's competitiveness in the global marketplace.

Scientific and Engineering Literacy

ALABAMA'S K-12 SCIENCE CURRICULUM
CONCEPTUAL FRAMEWORK

The goal of Alabama's K-12 science standards, as shown across the top of the conceptual framework graphic design on page 2, is the achievement of scientific and engineering literacy by all students. A scientifically literate person is one who has a foundation in scientific knowledge, a technological understanding of problem solving, and the ability to design scientific solutions. The correlation among these aspects of scientific literacy is depicted in the conceptual framework, which illustrates the three basic dimensions for establishing scientific and engineering literacy—scientific and engineering practices, crosscutting concepts, and disciplinary core ideas.

To face the many challenges of a universal society, Alabama students should be provided every opportunity to achieve scientific and engineering literacy from a global perspective as indicated by the image of Earth to the right of the goal statement. The infusion of a global science perspective into Alabama's curriculum is accomplished through a study of the three dimensions of science—scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Scientific and engineering practices are a set of skills and tools used by students to investigate, construct models, design and build systems, and develop theories about the world in which they live. Crosscutting concepts are unifying themes that link scientific and engineering ideas across all domains of science. Disciplinary core ideas in the four domains of Physical Sciences; Life Sciences; Earth and Space Sciences; and Engineering Technology, and Applications of Science are broad concepts that provide students with foundational knowledge. The three dimensions are depicted on the arrows that flow from the globe to the image of the state of Alabama where they are incorporated into the four domains that form the organizational structure for the content standards in this document.

The domains of Earth and Space Sciences; Physical Sciences; Life Sciences; and Engineering, Technology, and Applications of Science are displayed in the four quadrants in the graphic of the state of Alabama. The domain of Earth and Space Sciences is represented by a rocket, the image of an atom characterizes the Physical Sciences domain, and the gulf coastal area of the state symbolizes the Life Sciences domain. In the fourth quadrant are gears representing the meshing of the Engineering, Technology, and Applications of Science domain into each of the other domains. Each of the domains addresses the specific disciplinary core ideas of Dimension 3 as identified on page 12 of this document. Core ideas are the organizers for the content in each grade or course. However, the core ideas for the domain of Engineering, Technology, and Applications of Science are integrated into the content standards of the other three domains. The four domains continue from kindergarten through high school with concepts increasing in depth and rigor as students focus on deeper understanding and application of content.

The resulting science standards contained in this document ensure that Alabama students, having completed the K-12 science study, are informed science citizens and prepared college- and career-ready graduates. Having met the goal of attaining scientific and engineering literacy, these students will be able to achieve success in the global society of the twenty-first century and make meaningful contributions to a dynamic world.

POSITION STATEMENTS

Assessment

Assessment refers to the processes used to measure student progress and achievement by identifying patterns of qualitative and quantitative learning driven by instruction and feedback. Assessments provide evidence of students' prior knowledge, thinking, or learning in order to evaluate what students understand and how they are thinking at a given point in time for the purpose of promoting student learning. Consequently, science instruction should be informed by assessment, and instructional strategies should be adjusted based on feedback to meet the individual needs of all students. Assessment is aligned with curriculum and instruction and supports conceptual understanding with a focus on competency. Because no single assessment method provides a complete picture of what a student knows and can do, a variety of assessment methods is imperative. Ongoing formative assessments provide diagnostic feedback to teachers and students before, during, and after instruction. Formative assessment information should be used as feedback to modify teaching and learning activities. Summative assessments are used in classrooms, schools, and districts to determine student achievement at the end of a unit, course, or time period. Designers of assessments should consider the diverse backgrounds and different learning styles of students when planning for academic success in the classroom. Assessment tasks must integrate the three dimensions of science and engineering practices, crosscutting concepts, and disciplinary core ideas and provide opportunities for students to demonstrate conceptual understanding of science phenomena during inquiry. The primary goal of assessment is to measure with accuracy and validity what a student knows and can do and what a student still needs to learn based on Alabama's College- and Career-Readiness Standards.

Classroom Environment

Effective science classroom environments are those in which teachers and students work collaboratively. These student-centered environments shift the focus from the teacher to the learner, providing opportunities for creative scientific exploration and engineering design that allow students to connect the classroom to the outside world. Thus, stimulating the learner's interest in science through investigation encourages a lifelong pursuit for exploration and knowledge. The science classroom is any place where scientific inquiry occurs, whether it is the traditional laboratory or classroom, a playground, a science museum, an amusement park, a forest, or a beach. In the student-centered classroom, emphasis is placed upon active and cooperative learning environments where students work together to manipulate variables, make observations, and use prior knowledge to construct reasonable explanations while solving problems under conditions that assure both positive interdependence and individual accountability. Teachers guide and facilitate investigations by immersing students in scientific practices using inquiry, correct and appropriate manipulative techniques, and safe and humane laboratory practices. Students may be observed engaging in interpreting scientific data collected to construct and evaluate evidence-based arguments of phenomena during scientific inquiry or engaging in argument from evidence acquired during research of a phenomenon. Quality science instruction emphasizes critical thinking and investigative processes that reveal consistencies, relationships, and patterns. The classroom should be flexible, yet structured, intellectually challenging, positive and nonthreatening, stimulating, and adaptable to a variety of learning styles.

Cultural Diversity

Cultural diversity is an asset in the classroom. Educators should actively encourage students of various backgrounds to share their experiences in relation to science. Recognizing multicultural diversity in the classroom as a valuable resource contributes in positive ways to collaboration and participation in science learning.

Science and engineering are collaborative social processes that take place in the context of culturally valued knowledge and practices. Throughout history, diverse groups of people from different cultures and races have contributed to the body of scientific knowledge. This knowledge has resulted in remarkable technological advances that benefit all mankind. Today's global scientific community can be enhanced by the diverse perspectives represented by all nations, groups, and races. From a global perspective, engineering offers opportunities for innovation and creativity at the K-12 level. Engineering is a field that is critical to innovation, and exposure to engineering activities such as robotics and invention competitions can spark interest in the study of the science, technology, engineering, and mathematics (STEM) fields. This opportunity is particularly important for students who traditionally have not recognized science as relevant to their lives or future because of the lack of emphasis within the culture.

All students, regardless of gender, ethnicity, or cultural background, should have equal access to learning science and engaging in scientific and engineering practices. Strategies utilized for instruction must recognize and respect differences students bring based on their cultures. These standards provide an opportunity for schools to create environments that cultivate and prepare the minds of all students for greater understanding of the scientific enterprise. An increasing number of scientists and engineers are needed in our state and nation to continue technological advancement in many traditional and emerging scientific and engineering careers.

Instructional Model

Effective instruction results from deliberate and focused instructional design. This involves a shift in focus to the desired learning from which appropriate strategies will follow. As teachers shift the focus from teaching to student learning, they begin to spend most of the time considering what the learner needs in order to accomplish the learning goals instead of what the teacher will do and which materials the teacher will use. Effective instruction ensures that students are actively engaged in the learning process, have opportunities for interaction with the environment, and have time for reflection upon learning. The instructional setting must allow students time for developing the reasoning and critical-thinking skills necessary for constructing meaning and acquiring scientific knowledge. In this setting, teachers facilitate the learning process by guiding students, providing students with a focus, challenging students to excel, and encouraging and supporting student learning at all levels of inquiry. Before quality instruction can occur, there must be a plan for what teachers want students to learn. One process for planning includes the following three steps.

1. Identify desired outcomes found in the standards.
2. Determine acceptable evidence of student learning by designing evaluation activities.
3. Develop activities and learning experiences that will engage all students in exploring, explaining, and expanding their understanding of the scientific and engineering practices, crosscutting concepts, and disciplinary core ideas in the standards.

Members of the Alabama State Science Course of Study Committee and Task Force support the use of inquiry-based instructional models such as the following Five E + IA Instructional Model.* This model complements the three-step planning process described on the preceding page.

Five E + IA Instructional Model

Engage

Student interest is stimulated and connections are made to prior knowledge and between past and present experiences. Student thinking is focused on learning outcomes as they become mentally engaged in the practices, crosscutting concepts, and core ideas of the unit or lesson.

Explore

Students investigate initial ideas and solutions in a context within which they can identify. Using investigation, research, discourse, text, and media, students actively explore situations and build common experiences that serve as a basis for developing an understanding of the concept within context.

Explain

Students are provided the opportunity to collaborate, communicate, and construct meaning from their experiences based on an analysis of the exploration. This phase emphasizes the importance of students developing evidence-based explanations founded upon their observations and experiences obtained through investigations. Teachers clarify understanding through definitions, labels, and explanations for abilities, concepts, practices, and skills.

Elaborate

Students reflect upon, expand, and apply conceptual understanding of scientific concepts to new and unfamiliar situations in order to cultivate a broader and deeper understanding of concepts through new experiences within new contexts and situations.

Evaluate

Students are assessed on understanding of scientific concepts. Assessment provides opportunities for teachers to evaluate understanding of concepts and practices identified in the standards. This phase helps teachers know if students are learning in order for appropriate next steps to occur.

Intervene or **A**ccelerate

When some students do not learn the first time, intervention strategies may be implemented to further explain and elaborate upon concepts to a greater extent in order to clarify understanding. Students who have demonstrated proficiency may be able to enrich or accelerate learning through more challenging, engaging, and exploratory experiences.

*Adapted from Zuiker, Steven J., and J. Reid Whitaker (in preparation). "A Case Study of the STEMscopes 5E+I/A Inquiry Model." *Journal of Science Education and Technology*.

Interdisciplinary Connections

Academic rigor, critical-thinking skills, and vertically aligned learning progressions are common elements among Alabama's core academic standards. Diverse texts and media should be infused to create a rich science learning environment where students use real-world experiences and historical facts and events to discuss and create hypotheses and explain theories. Being able to read, write, and understand various media and texts in context are important skills to develop for both in and out of the classroom. Students write, speak, and create multimedia presentations based upon laboratory experiences and knowledge they obtained from published resources. The scientific and engineering practices allow students to utilize reading and writing skills (Appendix A). What is learned in English language arts classes is also learned and practiced in science when students construct explanations from evidence; engage in argument from evidence through debate to defend a claim; or obtain, evaluate, and communicate information from media, texts, and specifically through case studies. In both mathematics and science classes, students use computational thinking and mathematical representations to comprehend and communicate scientific findings. Students learn to develop and use models derived from data analyzed statistically to explain or describe phenomena. The creative element of science is found not only in discovery and invention, but is also realized in the artistic, scientific, and engineering designs developed by students. Science comes alive as students explore the natural world through the use of the five senses and produce sketches as a response to the observed environment while others write fiction and nonfiction to describe surroundings. At the same time, students may discover artifacts and native specimens which lead to discussions of history and geography of the area. High school students studying the disciplinary core idea, Heredity: Inheritance and Variation of Traits, may learn in science and world history about the important role hemophilia has played in Europe's history and communicate their findings orally or through writing. Students should also be able to develop an understanding of historical figures and events that have helped shape our world in the realm of science. Thus, it is essential for teachers to demonstrate how knowledge is interrelated and model strategies to recognize these connections.

Laboratory Safety

Active hands-on learning increases the potential for injuries or accidents. Safety is a primary concern for everyone in kindergarten through Grade 12, including students, teachers, support personnel, and administrators. For this reason, the National Science Teachers Association (NSTA) and the Alabama State Science Course of Study Committee and Task Force recommend that all science teachers be certified in first aid by the American Red Cross. Professional learning information may be accessed at http://www.redcross.org/take-a-class/certificates-ceus and http://www.redcross.org/take-a-class/program-highlights/cpr-first-aid. Before allowing students to participate in scientific investigations, teachers should recognize any potential for harm in order to prevent possible injuries or accidents or to minimize the impact of injuries or accidents if prevention is not successful.

Safety must be given a priority in the storage, use, and care of equipment, specimens, and materials in the science classroom. It is recommended that science teachers adhere to national regulatory agencies such as the American Chemical Society (ACS) and the Occupational Safety and Health Administration's (OSHA) revised Hazard Communication Standard (HCS), now aligned with the Globally Harmonized System (GHS) of Classification and Labeling of Chemicals, as well as local and state regulatory agencies that have established safety guidelines. In addition, teachers must work with the local school and local school system to be certain that science safety guidelines for which they are responsible are implemented.

Teachers must be certain that students receive adequate instruction for participating safely in all science investigations, no matter the location. As part of the safety guidelines, consideration must be given to adequate and safe space for scientific collaboration and investigation. To address this safety issue, professional organizations of science teachers recommend that science laboratory classes not exceed 24 students.

A written science safety plan is an essential part of the school science program. It is suggested that a science safety plan be developed by a team that includes the principal, teachers, school nurse, a fire fighter, and a representative from an insurance agency. Suggestions for developing science safety plans for schools and school systems are available on the Alabama Department of Education Web site at www.alsde.edu. After initial development, an annual review and assessment of the plan should be made to ensure its effectiveness.

Teachers should also be aware of the state safety goggle law found in the *Code of Alabama*, 1975, §16-1-7. This law requires local boards of education to provide American National Standard Institute (ANSI) Z87 or Z87.1 coded safety goggles to every student engaged in science experiments. Teachers are further encouraged to obtain and keep readily available the safety references, *Science and Safety—Making the Connection* for secondary classrooms and the *Science and Safety: It's Elementary!* calendar and flip chart. These publications are available to download free of charge from the Council of State Science Supervisors (CSSS) at http://csss-science.org/safety.shtml.

Nature of Science

Throughout history, humans have attempted to explain the natural world in which they live. Current scientific knowledge and engineering practices are the result of humankind's ongoing pursuit for answers to questions about natural phenomena. All scientists share the assumptions that the universe has order, consistency, and mathematically interpreted patterns. While there is no single pathway to discovering new scientific knowledge, all scientific models, theories, and laws are based on empirical evidence. Specifically, scientific theories can be defined as inferred explanations of observable events or phenomena. Scientific laws are statements of measurable relationships among observable events or phenomena. All scientific knowledge is open to revision in light of new evidence.

All scientific discourse is centered on common values of logical thinking, open-mindedness, objectivity, skepticism, reliability of research results, and honest reporting of findings. Science is fundamentally a human endeavor constrained by the progressing human capacity, technology, and social and economic contexts.

The 2012 National Research Council (NRC) publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* recognizes the importance of the nature of science by stating what an educated citizen should comprehend about the scientific enterprise. As indicated in the publication, there is strong agreement that students should understand and be able to distinguish among observations, hypotheses, inferences, models, and theories or unsubstantiated claims.

Science, Engineering, Technology, and Society

Advances in science and engineering have profound effects on human society, including agriculture, health care, transportation, and communication. At the same time, economic, political, and cultural factors influence the goals and funding for science and engineering research. The work of science is essential in addressing global issues such as the demand for energy, clean water, and food for Earth's growing population. On the other hand, science and engineering are needed to resolve problems created by human activity that draws on natural resources. A goal of science and engineering education is to equip students with the knowledge, skills, and dispositions that will help them grow into responsible consumers and wise managers of Earth's resources. Students should be able to contribute and engage in society as educated, literate science citizens who make responsible and informed decisions about what is appropriate in situations involving science and technology.

The Alabama State Science Course of Study Committee and Task Force recognize two specific important ideas that relate science, technology, and society. The first is that scientific inquiry, engineering design, and technological development are interdependent. Scientific discoveries allow engineers to perform their work, and engineering accomplishments enable the work of scientists. For example, discoveries of electricity made it possible for engineers to create power grids to illuminate cities and allow for communications. The Hubble Space Telescope and certain light sensors created by engineers expanded our understanding of the universe beyond existing astronomical knowledge. The second important idea is that scientific discoveries and technological decisions affect society and the natural environment. People make decisions that ultimately guide the work of scientists and engineers. The infusion of the engineering, technology, and applications of science domain to the science standards should serve as a vehicle for providing reliable sources of scientific and technological information to be used in the process of decision making.

The Alabama Department of Education supports science, technology, engineering, and mathematics (STEM) education through the Alabama Math, Science, and Technology Initiative (AMSTI), an outcome of the Alabama Mathematics, Science, Technology, and Engineering Coalition (AMSTEC), a network of state business, education, and public policy stakeholders working for systemic change in STEM education. AMSTI, designed by a Blue-Ribbon Committee of business leaders and K-12 and higher education representatives, is committed to the mission of affording all K-12 students with the knowledge and skills needed for college and career readiness in science, engineering, and technology. AMSTI, Alabama Science in Motion, the Southeastern Consortium of Minorities in Engineering (SECME), and Alabama Technology in Motion provide research-based practices for incorporating STEM education into classrooms.

Scientific Writing

Written communication in science is essential for conveying data and results from investigations, explaining evidence and findings from research, and affirming and defending claims and arguments based on evidence and reasoning. College- and career-ready writers should be able to utilize the most current technology and media to create, refine, and collaborate through writing. Writing as indicated in the Literacy Standards for Grades 6-12: History/Social Studies, Science, and Technical Subjects (Appendix A), should be emphasized across the curriculum. Students should be given opportunities to demonstrate writing skills to explain and document results of inquiries of scientific phenomena and concepts. Clear and coherent writing, developmentally appropriate for each grade level and reflecting knowledge and understanding through the use of accurate science academic language, is expected.

Writing activities such as scientific journals and laboratory reports should be introduced in the primary grades. During the middle and high school years, students should expand writing to completion of short or more extended inquiry or research projects using appropriate terminology, available technology, and suitable units of measurements. Students should be transitioning to the use of words and phrases with subject-specific meanings that differ from meanings used in everyday life. Discipline-specific discourse through oral or written language provides ways to communicate science core ideas. In addition, open-ended essays are an excellent way to assess student understanding of scientific concepts, principles and laws, scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. As learning progresses, students should develop more sophisticated methods of gathering information, evaluating sources, citing materials, and reporting findings from research. Students should devote significant time and effort to writing for a range of science tasks, purposes, and audiences.

LEARNING PROGRESSIONS

Content standards in the 2015 *Alabama Course of Study: Science* follow a logical learning progression that addresses the same disciplinary core ideas across multiple grade levels. While every core idea is not addressed in every consecutive grade, the core idea is taught through developmentally appropriate approaches with increasing rigor and sophistication in a continuous and progressive manner.

Learning progressions of content standards within Grades K-12 ensure that science concepts are not taught in isolation, but rather in the context of disciplinary core ideas that are introduced in earlier grades and are built upon in subsequent grades leading to the goal of scientific and engineering literacy. Examples of the learning progressions of content across three of the domains are found in the table below. These examples indicate the grade or course where the standard is located, followed by the content standard number**. K.3**, for example, specifies kindergarten, content standard number three.

PHYSICAL SCIENCES			
Motion and Stability: Forces and Interactions			
K-2	**3-5**	**6-8**	**9-12**
K.1. Investigate the resulting motion of objects when forces of different strengths and directions act upon them.	**3.1.** Plan and carry out an experiment to determine the effects of balanced and unbalanced forces on the motion of an object using one variable at a time, including number, size, direction, speed, position, friction, or air resistance, and communicate these findings graphically.	**8.9.** Use Newton's second law to demonstrate and explain how changes in an object's motion depend on the sum of the forces on the object and the mass of the object.	**Physical Science.8.** Apply Newton's laws to predict the resulting motion of a system by constructing force diagrams that identify the forces acting on the system, including friction. **Physics.2.** Identify forces in a system and apply Newton's laws graphically by using models such as free-body diagrams to explain how the motion of an object is affected, ranging from simple to complex, and including circular motion.
LIFE SCIENCES			
Ecosystems: Interactions, Energy, and Dynamics			
K-2	**3-5**	**6-8**	**9-12**
K.3. Distinguish between living and nonliving things and verify what living things need to survive.	**5.11.** Create a model to illustrate the transfer of matter among producers; consumers, including scavengers and decomposers; and the environment.	**7.5.** Examine the cycling of matter between abiotic and biotic parts of ecosystems to explain the flow of energy and the conservation of matter.	**Biology.8.** Develop and use models to describe the cycling of matter and flow of energy between abiotic and biotic factors in ecosystems.
EARTH AND SPACE SCIENCES			
Earth's Systems			
K-2	**3-5**	**6-8**	**9-12**
2.8. Make observations from media to obtain information about Earth events that happen over a short period of time or over a time period longer than one can observe.	**4.12.** Construct explanations by citing evidence found in patterns of rock formations and fossils in rock layers that Earth changes over time through both slow and rapid processes.	**6.5.** Use evidence to explain how different geologic processes shape Earth's history over widely varying scales of space and time.	**Earth and Space Science.9.** Obtain, evaluate, and communicate information to explain how constructive and destructive processes shape Earth's land features and sea features.

STRUCTURE OF THE STANDARDS

Each content standard in this document addresses the three scientific dimensions listed below and as described in the 2012 National Research Council (NRC) publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Standards outline the knowledge and skills of science and engineering that all students should know and be able to do by the end of high school.

DIMENSION 1: SCIENTIFIC AND ENGINEERING PRACTICES

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

DIMENSION 2: CROSSCUTTING CONCEPTS

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function
- Stability and change

DIMENSION 3: DISCIPLINARY CORE IDEAS

- Physical Sciences
  - ➢ Matter and Its Interactions
  - ➢ Motion and Stability: Forces and Interactions
  - ➢ Energy
  - ➢ Waves and Their Applications in Technologies for Information Transfer

- Life Sciences
  - ➢ From Molecules to Organisms: Structures and Processes
  - ➢ Ecosystems: Interactions, Energy, and Dynamics
  - ➢ Heredity: Inheritance and Variation of Traits
  - ➢ Unity and Diversity

- Earth and Space Sciences
  - ➢ Earth’s Place in the Universe
  - ➢ Earth’s Systems
  - ➢ Earth and Human Activity

- Engineering, Technology, and Applications of Science
  - ➢ Engineering Design
  - ➢ Links Among Engineering, Technology, Science, and Society

DIRECTIONS FOR INTERPRETING THE MINIMUM REQUIRED CONTENT

Academic content standards in this document are divided into grade clusters K-2, 3-5, 6-8, and 9-12. Each cluster contains an overview that provides general information regarding student characteristics, the classroom environment, and science instruction. More specific information for each grade level or course, including scientific and engineering practices, crosscutting concepts, and disciplinary core ideas, is provided in the description that precedes the content standards for that grade or course.

The illustrations below and on the next page are intended to serve as guides for interpreting the Grades K-12 minimum required content. The required content addresses what all students should know and be able to do by the end of a grade or course.

Disciplinary Core Ideas, identified in Dimension 3 on page 12 of this document, are the recurring ideas from the three science domains of Physical Sciences, Life Sciences, and Earth and Space Sciences. The core ideas are the key organizing principles from a domain that are teachable and learnable over multiple grades or increasing levels of depth and sophistication. The core idea is accessible to younger students but is broad enough to maintain continued investigation through high school. As shown below, the core ideas appear in the shaded bands that precede the content standards.

Content Standards are written below each disciplinary core idea as indicated in the illustration. The standards are assessable statements of what students should know and be able to do as a result of instruction. The order in which standards are listed within a grade or course is not intended to convey a sequence for instruction or to dictate curriculum or teaching methods. Each content standard completes the phrase *"Students will."*

Related Content is listed alphabetically under a standard. Related content is required for instruction.

Examples, shown in parentheses and indicated by e.g., are intended to clarify the standards or related content. Examples are illustrative, but not exhaustive, and are not required content.

GRADE 6 – EARTH AND SPACE SCIENCE

Disciplinary Core Idea

Students will:

Earth's Systems

Content Standard

12. Integrate qualitative scientific and technical information (e.g., weather maps, diagrams, other visualizations, including radar and computer simulations) to support the claim that motions and complex interactions of air masses result in changes in weather conditions.
    a. Use various instruments (e.g., thermometers, barometers, anemometers, wet bulbs) to monitor local weather and examine weather patterns to predict various weather events, especially the impact of severe weather (e.g., fronts, hurricanes, tornados, blizzards, ice storms, droughts).

Related Content

Examples

Engineering Practices are embedded in the content standards throughout the three science domains in each grade level or course. These practices emphasize the engineering, technology, and applications of science core ideas. Standards containing these practices are denoted with an asterisk (*). An example appears below.

GRADES 9-12 - PHYSICAL SCIENCE

Students will:

Energy

12. Design, build, and test the ability of a device (e.g., Rube Goldberg devices, wind turbines, solar cells, solar ovens) to convert one form of energy into another form of energy.*

Engineering Practice Standard

Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Content, the three dimensions of science, are incorporated into each of the content standards throughout the K-12 science curriculum. Examples of the dimensions as they appear in a standard are illustrated below.

GRADE 2

Students will:

Earth and Human Activity

11. Examine and test solutions that address changes caused by Earth's events (e.g., dams for minimizing flooding, plants for controlling erosion).*

Disciplinary Core Content

Scientific/Engineering Practice

Crosscutting Concept

GRADES K-2
Overview

Science education in Grades K-2 provides students with a foundation for the lifelong pursuit of scientific information and exploration. Young children are natural scientists and possess a curiosity and eagerness to learn about the world around them. They are able to construct knowledge and gather information through the use of the five senses. Learning about science in the early years is a multifaceted task and requires a range of student experiences to support diverse learning styles.

The early childhood classroom environment must stimulate the natural curiosity and capitalize on the energy level of the young learner while providing a safe and supportive environment that appeals to all students. Key components of this educational environment include a meaningful curriculum, high-quality instruction, and effective assessment that drives instruction. The young student is a concrete learner in need of many opportunities to interact in hands-on, inquiry-based investigations and cooperative learning situations.

The K-2 science content creates a sound base for scientific exploration and acquisition of knowledge and skills in a developmentally appropriate manner. Effective science instruction in Grades K-2 includes instructional strategies guided by the content standards that address the three dimensions of scientific and engineering practices, crosscutting concepts, and disciplinary core ideas.

GRADE K

Kindergarten students enter school with an eagerness to explore the world around them. Although their experiences and background knowledge may be limited, science instruction provides ample opportunities to develop investigative thinking, argumentation, and reasoning in the context of familiar surroundings. Students develop the foundational skills necessary for future learning in science.

Students in kindergarten learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students investigate forces and interactions. In Life Science, students explore interactions, energy, and dynamics of ecosystems. In Earth and Space Science, students become familiar with Earth's systems while observing the effects of sunlight and studying weather patterns. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three scientific domains and are denoted with an asterisk (*).

Grade K content standards provide students with opportunities for appropriate investigation and observation of the world around them. Through guided participation in specific engineering design projects, they find answers regarding how to use force to change the speed or direction of an object, how to reduce the human impact on the local environment, how to reduce the effects of sunlight, and how to use weather forecasts to prepare for severe weather.

Students will:

Motion and Stability: Forces and Interactions

1. Investigate the resulting motion of objects when forces of different strengths and directions act upon them (e.g., object being pushed, object being pulled, two objects colliding).

2. Use observations and data from investigations to determine if a design solution (e.g., designing a ramp to increase the speed of an object in order to move a stationary object) solves the problem of using force to change the speed or direction of an object.*

Ecosystems: Interactions, Energy, and Dynamics

3. Distinguish between living and nonliving things and verify what living things need to survive (e.g., animals needing food, water, and air; plants needing nutrients, water, sunlight, and air).

4. Gather evidence to support how plants and animals provide for their needs by altering their environment (e.g., tree roots breaking a sidewalk to provide space, red fox burrowing to create a den to raise young, humans growing gardens for food and building roads for transportation).

5. Construct a model of a natural habitat (e.g., terrarium, ant farm, diorama) conducive to meeting the needs of plants and animals native to Alabama.

6. Identify and plan possible solutions (e.g., reducing, reusing, recycling) to lessen the human impact on the local environment.*

Earth's Systems

7. Observe and describe the effects of sunlight on Earth's surface (e.g., heat from the sun causing evaporation of water or increased temperature of soil, rocks, sand, and water).

8. Design and construct a device (e.g., hat, canopy, umbrella, tent) to reduce the effects of sunlight.*

9. Observe, record, and share findings of local weather patterns over a period of time (e.g., increase in daily temperature from morning to afternoon, typical rain and storm patterns from season to season).

Earth and Human Activity

10. Ask questions to obtain information about the purpose of weather forecasts in planning for, preparing for, and responding to severe weather.*

GRADE 1

First-grade students continue to be eager learners who are curious about their world. This inquisitive nature leads them to ask a variety of questions that deepen understanding. Students are developing social skills that enable them to interact in inquiry-based and cooperative-learning opportunities. Students begin to take ownership of their learning experiences by making connections through meaningful investigations.

Students in Grade 1 learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students conduct experiments to discover the properties of light and sound waves. In Life Science, students determine similarities between parents and their offspring and how organisms adapt to their environment. In Earth and Space Science, students continue to explore Earth's systems through observations of seasonal patterns as well as patterns in the day and night sky. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three science domains and are denoted with an asterisk (*).

Grade 1 content standards provide students with opportunities for appropriate investigation and observation of the world around them. Through guided participation in specific engineering design projects, they find answers regarding how to use light or sound to communicate and how humans can imitate plant or animal parts for survival or protection.

Students will:

Waves and Their Applications in Technologies for Information Transfer

1. Conduct experiments to provide evidence that vibrations of matter can create sound (e.g., striking a tuning fork, plucking a guitar string) and sound can make matter vibrate (e.g., holding a piece of paper near a sound system speaker, touching your throat while speaking).

2. Construct explanations from observations that objects can be seen only when light is available to illuminate them (e.g., moon being illuminated by the sun, colors and patterns in a kaleidoscope being illuminated when held toward a light).

3. Investigate materials to determine which types allow light to pass through (e.g., transparent materials such as clear plastic wrap), allow only partial light to pass through (e.g., translucent materials such as wax paper), block light (e.g., opaque materials such as construction paper), or reflect light (e.g., shiny materials such as aluminum foil).

4. Design and construct a device that uses light or sound to send a communication signal over a distance (e.g., using a flashlight and a piece of cardboard to simulate a signal lamp for sending a coded message to a classmate, using a paper cup and string to simulate a telephone for talking to a classmate).*

From Molecules to Organisms: Structures and Processes

5. Design a solution to a human problem by using materials to imitate how plants and/or animals use their external parts to help them survive, grow, and meet their needs (e.g., outerwear imitating animal furs for insulation, gear mimicking tree bark or shells for protection).*

6. Obtain information to provide evidence that parents and their offspring engage in patterns of behavior that help the offspring survive (e.g., crying of offspring indicating need for feeding, quacking or barking by parents indicating protection of young).

Heredity: Inheritance and Variation of Traits

7. Make observations to identify the similarities and differences of offspring to their parents and to other members of the same species (e.g., flowers from the same kind of plant being the same shape, but differing in size; dog being same breed as parent, but differing in fur color or pattern).

Earth's Place in the Universe

8. Observe, describe, and predict patterns of the sun, moon, and stars as they appear in the sky (e.g., sun and moon appearing to rise in one part of the sky, move across the sky, and set; stars other than our sun being visible at night, but not during the day).

9. Observe seasonal patterns of sunrise and sunset to describe the relationship between the number of hours of daylight and the time of year (e.g., more hours of daylight during summer as compared to winter).

GRADE 2

Second-grade students begin the school year with prior knowledge and skills that enable them to formulate answers to questions as they expand their comprehension of the world around them. Through continued exploration, they develop an understanding of the observable properties of materials and apply this understanding to the acquisition of new information and the construction of new models.

Students in Grade 2 learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students explore the physical properties and structure of matter. In Life Science, students explore plant needs and interactions within their habitats. In Earth and Space Science, students observe and identify Earth's events and physical features. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three scientific domains and are denoted with an asterisk (*).

Grade 2 content standards provide students with opportunities for appropriate exploration and observation of the world around them. Through guided participation in specific engineering design projects, they find answers regarding how properties of materials determine appropriate uses, how plants depend on animals for seed dispersal and pollination, and how to address changes caused by Earth events.

Students will:

Matter and Its Interactions

1. Conduct an investigation to describe and classify various substances according to physical properties (e.g., milk being a liquid, not clear in color, assuming shape of its container, mixing with water; mineral oil being a liquid, clear in color, taking shape of its container, floating in water; a brick being a solid, not clear in color, rough in texture, not taking the shape of its container, sinking in water).

2. Collect and evaluate data to determine appropriate uses of materials based on their properties (e.g., strength, flexibility, hardness, texture, absorbency).*

3. Demonstrate and explain how structures made from small pieces (e.g., linking cubes, blocks, building bricks, creative construction toys) can be disassembled and then rearranged to make new and different structures.

4. Provide evidence that some changes in matter caused by heating or cooling can be reversed (e.g., heating or freezing of water) and some changes are irreversible (e.g., baking a cake, boiling an egg).

Ecosystems: Interactions, Energy, and Dynamics

5. Plan and carry out an investigation, using one variable at a time (e.g., water, light, soil, air), to determine the growth needs of plants.

6. Design and construct models to simulate how animals disperse seeds or pollinate plants (e.g., animals brushing fur against seed pods and seeds falling off in other areas, birds and bees extracting nectar from flowers and transferring pollen from one plant to another).*

7. Obtain information from literature and other media to illustrate that there are many different kinds of living things and that they exist in different places on land and in water (e.g., woodland, tundra, desert, rainforest, ocean, river).

Earth's Systems

8. Make observations from media to obtain information about Earth events that happen over a short period of time (e.g., tornados, volcanic explosions, earthquakes) or over a time period longer than one can observe (e.g., erosion of rocks, melting of glaciers).

9. Create models to identify physical features of Earth (e.g., mountains, valleys, plains, deserts, lakes, rivers, oceans).

10. Collect and evaluate data to identify water found on Earth and determine whether it is a solid or a liquid (e.g., glaciers as solid forms of water; oceans, lakes, rivers, streams as liquid forms of water).

Earth and Human Activity

11. Examine and test solutions that address changes caused by Earth's events (e.g., dams for minimizing flooding, plants for controlling erosion).*

GRADES 3-5
Overview

In Grades 3-5, students are introduced to disciplinary core ideas and crosscutting concepts in the domains of Physical Science; Life Science; Earth and Space Science; and Engineering, Technology, and Applications of Science through content and participation in scientific and engineering practices. Direct experiences with physical models and materials remain important as students develop their ability to reason and communicate in multimodal scientific contexts. Students in Grades 3-5 ask increasingly sophisticated questions that stem from their observations, experiences, and prior learning. While students engage in the practices of science and engineering, they revise and extend their understanding of the role of science in the natural and technological environments in which they live. Physical evidence derived from numeric measurements and recorded data becomes an important part of students' emerging scientific explanations.

Learning environments in Grades 3-5 encourage a full range of inquiry, including opportunities to carry out scientific investigations and engineering design projects related to the disciplinary core ideas. Students engage in written and oral communication about the texts they read, the phenomena they observe, and the conclusions they draw from their scientific investigations and engineering projects. The role of mathematics becomes increasingly important as students produce and present numerical data in various forms such as tables and graphs. Being engaged in learning environments where content knowledge and scientific and engineering practices are intertwined, helps students develop more scientifically accurate and coherent conceptions of the laws and principles that govern the physical world.

Effective science instruction in Grades 3-5 provides students with opportunities for a variety of scientific activities and scientific thinking. Classroom experiences include investigations that range from those structured by the teacher to those that emerge from students' own questions. Students have opportunities to decide which data to gather, the variables that should be controlled, and which tools and instruments are needed to carry out investigations. Through participation in scientific and engineering practices, students develop their abilities to work in groups to design solutions to problems stemming from real-world scientific scenarios. Domain-specific core ideas, crosscutting concepts, and performance expectations within the content standards create a framework for instructional planning and student learning.

GRADE 3

Grade 3 students are increasingly aware of their environment and have already discovered many patterns and processes in nature. Their capacity to process information is growing, making them eager to participate in scientific and engineering practices. Writing and mathematics skills are used when students communicate scientific information during varied instructional activities.

Students in Grade 3 learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students investigate, measure, and predict the motion of an object and test the cause-and-effect relationship of electric and magnetic interactions. In Life Science, students use evidence to interpret fossil data and construct explanations of an organism's ability to survive in different habitats. Students examine organisms' life cycles and traits and the influence of environment on these traits. In Earth and Space Science, students develop representations to describe weather and climate. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three scientific domains and are denoted with an asterisk (*).

Grade 3 content standards provide students with opportunities for investigation, observation, and interpretation of a variety of scientific phenomena. Through participation in specific engineering design challenges, they find solutions regarding how to use magnets to solve a simple design problem, how to solve problems created by environmental changes, and how to reduce the impact of weather-related hazards.

Students will:

Motion and Stability: Forces and Interactions

1. Plan and carry out an experiment to determine the effects of balanced and unbalanced forces on the motion of an object using one variable at a time, including number, size, direction, speed, position, friction, or air resistance (e.g., balanced forces pushing from both sides on an object, such as a box, producing no motion; unbalanced force on one side of an object, such as a ball, producing motion), and communicate these findings graphically.

2. Investigate, measure, and communicate in a graphical format how an observed pattern of motion (e.g., a child swinging in a swing, a ball rolling back and forth in a bowl, two children teetering on a see-saw, a model vehicle rolling down a ramp of varying heights, a pendulum swinging) can be used to predict the future motion of an object.

3. Explore objects that can be manipulated in order to determine cause-and-effect relationships (e.g., distance between objects affecting strength of a force, orientation of magnets affecting direction of a magnetic force) of electric interactions between two objects not in contact with one another (e.g., force on hair from an electrically charged balloon, electrical forces between a charged rod and pieces of paper) or magnetic interactions between two objects not in contact with one another (e.g., force between two permanent magnets or between an electromagnet and steel paperclips, force exerted by one magnet versus the force exerted by two magnets).

4. Apply scientific ideas about magnets to solve a problem through an engineering design project (e.g., constructing a latch to keep a door shut, creating a device to keep two moving objects from touching each other such as a maglev system).*

From Molecules to Organisms: Structures and Processes

5. Obtain and combine information to describe that organisms are classified as living things, rather than nonliving things, based on their ability to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing external environment.

6. Create representations to explain the unique and diverse life cycles of organisms other than humans (e.g., flowering plants, frogs, butterflies), including commonalities such as birth, growth, reproduction, and death.

Heredity: Inheritance and Variation of Traits

7. Examine data to provide evidence that plants and animals, excluding humans, have traits inherited from parents and that variations of these traits exist in groups of similar organisms (e.g., flower colors in pea plants, fur color and pattern in animal offspring).

8. Engage in argument from evidence to justify that traits can be influenced by the environment (e.g., stunted growth in normally tall plants due to insufficient water, change in an arctic fox's fur color due to light and/or temperature, stunted growth of a normally large animal due to malnourishment).

Unity and Diversity

9. Analyze and interpret data from fossils (e.g., type, size, distribution) to provide evidence of organisms and the environments in which they lived long ago (e.g., marine fossils on dry land, tropical plant fossils in arctic areas, fossils of extinct organisms in any environment).

10. Investigate how variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing (e.g., plants having larger thorns being less likely to be eaten by predators, animals having better camouflage coloration being more likely to survive and bear offspring).

11. Construct an argument from evidence to explain the likelihood of an organism's ability to survive when compared to the resources in a certain habitat (e.g., freshwater organisms survive well, less well, or not at all in saltwater; desert organisms survive well, less well, or not at all in woodlands).
    a. Construct explanations that forming groups helps some organisms survive.
    b. Create models that illustrate how organisms and their habitats make up a system in which the parts depend on each other.
    c. Categorize resources in various habitats as basic materials (e.g., sunlight, air, freshwater, soil), produced materials (e.g., food, fuel, shelter), or as nonmaterial (e.g., safety, instinct, nature-learned behaviors).

12. Evaluate engineered solutions to a problem created by environmental changes and any resulting impacts on the types and density of plant and animal populations living in the environment (e.g., replanting of sea oats in coastal areas due to destruction by hurricanes, creating property development restrictions in vacation areas to reduce displacement and loss of native animal populations).*

Earth's Systems

13. Display data graphically and in tables to describe typical weather conditions expected during a particular season (e.g., average temperature, precipitation, wind direction).

14. Collect information from a variety of sources to describe climates in different regions of the world.

Earth and Human Activity

15. Evaluate a design solution (e.g., flood barriers, wind resistant roofs, lightning rods) that reduces the impact of a weather-related hazard.*

GRADE 4

Grade 4 students' view of the natural world includes many scientifically accurate components. They recognize the role of evidence in scientific thinking and are beginning to include evidence in their scientific explanations. Fourth graders enjoy an active learning environment with opportunities to manipulate physical materials and construct models.

Fourth-grade students learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students construct explanations based on evidence connecting the speed of an object to the energy of that object, including the transference of energy in its various forms. They obtain information about sources, uses, and environmental effects of renewable and nonrenewable energy resources. Additionally, fourth-grade students analyze wave patterns with observable wavelengths and amplitudes. In Life Science, students compare the internal and external structures of plants and animals, obtain and communicate information about human body systems, and investigate ways animals process information. In Earth and Space Science, Grade 4 students examine evidence to construct explanations for both slow and rapid changes on Earth's land features, describe patterns of Earth's land and water based on maps, and carry out investigations relating to erosion. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three scientific domains and are denoted with an asterisk (*).

Grade 4 content standards provide students with opportunities for investigation, observation, and explanation of a variety of scientific phenomena. Through participation in specific engineering design projects, they find answers regarding which components of a device change energy from one form to another, how wave patterns can be used to transfer information, and how to limit the effects of harmful natural Earth processes on human life.

Students will:

Energy

1. Use evidence to explain the relationship of the speed of an object to the energy of that object.

2. Plan and carry out investigations that explain transference of energy from place to place by sound, light, heat, and electric currents.
    a. Provide evidence that heat can be produced in many ways (e.g., rubbing hands together, burning leaves) and can move from one object to another by conduction.
    b. Demonstrate that different objects can absorb, reflect, and/or conduct energy.
    c. Demonstrate that electric circuits require a complete loop through which an electric current can pass.

3. Investigate to determine changes in energy resulting from increases or decreases in speed that occur when objects collide.

4. Design, construct, and test a device that changes energy from one form to another (e.g., electric circuits converting electrical energy into motion, light, or sound energy; a passive solar heater converting light energy into heat energy).*

5. Compile information to describe how the use of energy derived from natural renewable and nonrenewable resources affects the environment (e.g., constructing dams to harness energy from water, a renewable resource, while causing a loss of animal habitats; burning of fossil fuels, a nonrenewable resource, while causing an increase in air pollution; installing solar panels to harness energy from the sun, a renewable resource, while requiring specialized materials that necessitate mining).

Waves and Their Applications in Technologies for Information Transfer

6. Develop a model of waves to describe patterns in terms of amplitude and wavelength, and including that waves can cause objects to move.

7. Develop and use models to show multiple solutions in which patterns are used to transfer information (e.g., using a grid of 1s and 0s representing black and white to send information about a picture, using drums to send coded information through sound waves, using Morse code to send a message).*

8. Construct a model to explain that an object can be seen when light reflected from its surface enters the eyes.

From Molecules to Organisms: Structures and Processes

9. Examine evidence to support an argument that the internal and external structures of plants (e.g., thorns, leaves, stems, roots, colored petals, xylem, phloem) and animals (e.g., heart, stomach, lung, brain, skin) function to support survival, growth, behavior, and reproduction.

10. Obtain and communicate information explaining that humans have systems that interact with one another for digestion, respiration, circulation, excretion, movement, control, coordination, and protection from disease.

11. Investigate different ways animals receive information through the senses, process that information, and respond to it in different ways (e.g., skunks lifting tails and spraying an odor when threatened, dogs moving ears when reacting to sound, snakes coiling or striking when sensing vibrations).

Earth's Systems

12. Construct explanations by citing evidence found in patterns of rock formations and fossils in rock layers that Earth changes over time through both slow and rapid processes (e.g., rock layers containing shell fossils appearing above rock layers containing plant fossils and no shells indicating a change from land to water over time, a canyon with different rock layers in the walls and a river in the bottom indicating that over time a river cut through the rock).

13. Plan and carry out investigations to examine properties of soils and soil types (e.g., color, texture, capacity to retain water, ability to support growth of plants).

14. Explore information to support the claim that landforms are the result of a combination of constructive forces, including crustal deformation, volcanic eruptions, and sediment deposition as well as a result of destructive forces, including erosion and weathering.

15. Analyze and interpret data (e.g., angle of slope in downhill movement of water, volume of water flow, cycles of freezing and thawing of water, cycles of heating and cooling of water, speed of wind, relative rate of soil deposition, amount of vegetation) to determine effects of weathering and rate of erosion by water, ice, wind, and vegetation using one single form of weathering or erosion at a time.

16. Describe patterns of Earth's features on land and in the ocean using data from maps (e.g., topographic maps of Earth's land and ocean floor; maps of locations of mountains, continental boundaries, volcanoes, and earthquakes).

17. Formulate and evaluate solutions to limit the effects of natural Earth processes on humans (e.g., designing earthquake, tornado, or hurricane-resistant buildings; improving monitoring of volcanic activity).*

GRADE 5

Grade 5 students have developed many skills that enable them to conduct more refined measurements of data and communicate scientific information with greater detail through various forms of presentation. They are able to recognize the process needed for planning and carrying out investigations, relate numeric relationships to patterns discovered in data, and identify the role of design solutions to problems occurring in real life. Many fifth graders are emerging scientific thinkers. An encouraging and challenging learning environment can inspire fifth graders to develop a passion for science and engineering.

Fifth-grade students learn disciplinary core ideas from the three scientific domains of Physical, Life, and Earth and Space Sciences while demonstrating their learning in the context of the content standards for this grade level. In Physical Science, students classify matter based on its physical and chemical properties and carry out investigations to provide evidence of the principle of conservation of matter. In Life Science, they develop models to explain the flow of energy and matter in ecosystems, including classifying resources into living and nonliving and classifying organisms into producers, consumers, and decomposers. In Earth and Space Science, students use multiple ways to illustrate the distribution of water on Earth and the interaction of the atmosphere, biosphere, geosphere, and hydrosphere. Students obtain information about ways individuals and communities can protect Earth's resources and environment. Fifth graders find evidence of the gravitational force that pulls all objects downward, evaluate factors that cause some stars to shine more brightly than others, and construct explanations for the patterns of seasons, day and night, and the seasonal changes of stars visible in the sky. The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are integrated within the content standards of the three scientific domains and are denoted with an asterisk (*).

Grade 5 content standards provide students with opportunities for investigation, observation, and explanation of a variety of scientific phenomena. Through participation in specific engineering design projects, students find answers regarding which methods can be used to clean a polluted environment and how to modify the speed of a falling object due to gravity.

Students will:

Matter and Its Interactions

1. Plan and carry out investigations (e.g., adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, evaporating salt water) to provide evidence that matter is made of particles too small to be seen.

2. Investigate matter to provide mathematical evidence, including graphs, to show that regardless of the type of reaction (e.g., new substance forming due to dissolving or mixing) or change (e.g., phase change) that occurs when heating, cooling, or mixing substances, the total weight of the matter is conserved.

3. Examine matter through observations and measurements to identify materials (e.g., powders, metals, minerals, liquids) based on their properties (e.g., color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, solubility, density).

4. Investigate whether the mixing of two or more substances results in new substances (e.g., mixing of baking soda and vinegar resulting in the formation of a new substance, gas; mixing of sand and water resulting in no new substance being formed).

5. Construct explanations from observations to determine how the density of an object affects whether the object sinks or floats when placed in a liquid.

Motion and Stability: Forces and Interactions

6. Construct an explanation from evidence to illustrate that the gravitational force exerted by Earth on objects is directed downward towards the center of Earth.

7. Design and conduct a test to modify the speed of a falling object due to gravity (e.g., constructing a parachute to keep an attached object from breaking).*

Ecosystems: Interactions, Energy, and Dynamics

8. Defend the position that plants obtain materials needed for growth primarily from air and water.

9. Construct an illustration to explain how plants use light energy to convert carbon dioxide and water into a storable fuel, carbohydrates, and a waste product, oxygen, during the process of photosynthesis.

10. Construct and interpret models (e.g., diagrams, flow charts) to explain that energy in animals' food is used for body repair, growth, motion, and maintenance of body warmth and was once energy from the sun.

11. Create a model to illustrate the transfer of matter among producers; consumers, including scavengers and decomposers; and the environment.

Earth's Place in the Universe

12. Defend the claim that one factor determining the apparent brightness of the sun compared to other stars is the relative distance from Earth.

13. Analyze data and represent with graphs to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky (e.g., shadows and the position and motion of Earth with respect to the sun, visibility of select stars only in particular months).

Earth's Systems

14. Use a model to represent how any two systems, specifically the atmosphere, biosphere, geosphere, and/or hydrosphere, interact and support life (e.g., influence of the ocean on ecosystems, landform shape, and climate; influence of the atmosphere on landforms and ecosystems through weather and climate; influence of mountain ranges on winds and clouds in the atmosphere).

15. Identify the distribution of freshwater and salt water on Earth (e.g., oceans, lakes, rivers, glaciers, ground water, polar ice caps) and construct a graphical representation depicting the amounts and percentages found in different reservoirs.

Earth and Human Activity

16. Collect and organize scientific ideas that individuals and communities can use to protect Earth's natural resources and its environment (e.g., terracing land to prevent soil erosion, utilizing no-till farming to improve soil fertility, regulating emissions from factories and automobiles to reduce air pollution, recycling to reduce overuse of landfill areas).

17. Design solutions, test, and revise a process for cleaning a polluted environment (e.g., simulating an oil spill in the ocean or a flood in a city and creating a solution for containment and/or cleanup).*

GRADES 6-8
Overview

Students in Grades 6-8 develop independent, critical-thinking skills during a time when their bodies experience dramatic emotional changes and their minds shift from concrete to more conceptual thinking. Their curiosity, sense of purpose, and intellectual interests expand and mature. Middle school students are sensitive to peer perception and prefer interaction with peers during learning activities. Students possess multiple learning styles and a wide range of intellectual abilities. Teachers are challenged to incorporate effective instructional strategies using scientific, engineering, and technological practices that meet students' growing needs as individual learners while providing a safe, engaging learning environment.

Earth and Space Science, Life Science, and Physical Science content and skills are best taught through the integration of scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. Students evaluate scientific evidence and engage in data-driven discussions about scientific concepts through peer review and independent verification. Precision and accuracy become more applicable to investigations as students use the International System of Units (SI) and dimensional analysis in their interpretation of empirical data. Students refine their understanding through comparisons, observations, and examinations of information gathered from experiences. By implementing a more rigorous, student-centered curriculum, science teachers enable students to become actively involved in their own learning.

Success in science creates independent, analytical, lifelong learners capable of meeting the needs and challenges of the twenty-first century. Students learn how scientific knowledge is acquired and how scientific explanations are developed. Through the engineering design process and the use of engineering, technology, and applications of science, students develop their abilities to work in cooperative groups to design solutions to problems encountered in the real world.

GRADE 6
Earth and Space Science

Grade 6 students are energetic and curious. They are maturing at a rapid rate and are in a transitional stage characterized by physical, social, and cognitive changes. The sixth-grade classroom environment addresses these changes by providing a balance between elementary and middle school practices. While these changes lead students toward emotional and academic independence, sixth graders continue to need guidance. They also need an environment that both supports and challenges them as they become more responsible learners.

Content standards challenge students to discover their world, their planet, and Earth's place in the universe. Students are provided opportunities to learn important scientific facts and to build conceptual understanding of scientific principles, laws, and theories. Students must understand and communicate scientific concepts in order to be scientifically literate. Inquiry-based instruction allows them to develop critical-thinking skills and problem-solving abilities needed in the field of science.

Grade 6 content focuses on the disciplinary core ideas in the Earth and Space Science domain. The first Earth and Space Science core idea, Earth's Place in the Universe, describes the universe as a whole and addresses its grand scale in both space and time. The second core idea, Earth's Systems, encompasses the processes that drive Earth's conditions and its continual change over time. The third core idea, Earth and Human Activity, addresses society's interactions with the planet. Integrated within the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to employ tools and materials to solve problems and to use representations to convey various design solutions. ETS standards are denoted with an asterisk (*).

Students will:

Earth's Place in the Universe

1. Create and manipulate models (e.g., physical, graphical, conceptual) to explain the occurrences of day/night cycles, length of year, seasons, tides, eclipses, and lunar phases based on patterns of the observed motions of celestial bodies.

2. Construct models and use simulations (e.g., diagrams of the relationship between Earth and man-made satellites, rocket launch, International Space Station, elliptical orbits, black holes, life cycles of stars, orbital periods of objects within the solar system, astronomical units and light years) to explain the role of gravity in affecting the motions of celestial bodies (e.g., planets, moons, comets, asteroids, meteors) within galaxies and the solar system.

3. Develop and use models to determine scale properties of objects in the solar system (e.g., scale model representing sizes and distances of the sun, Earth, moon system based on a one-meter diameter sun).

Earth's Systems

4. Construct explanations from geologic evidence (e.g., change or extinction of particular living organisms; field evidence or representations, including models of geologic cross-sections; sedimentary layering) to identify patterns of Earth's major historical events (e.g., formation of mountain chains and ocean basins, significant volcanic eruptions, fossilization, folding, faulting, igneous intrusion, erosion).

5. Use evidence to explain how different geologic processes shape Earth's history over widely varying scales of space and time (e.g., chemical and physical erosion; tectonic plate processes; volcanic eruptions; meteor impacts; regional geographical features, including Alabama fault lines, Rickwood Caverns, and Wetumpka Impact Crater).

6. Provide evidence from data of the distribution of fossils and rocks, continental shapes, and seafloor structures to explain past plate motions.

7. Use models to construct explanations of the various biogeochemical cycles of Earth (e.g., water, carbon, nitrogen) and the flow of energy that drives these processes.

8. Plan and carry out investigations that demonstrate the chemical and physical processes that form rocks and cycle Earth materials (e.g., processes of crystallization, heating and cooling, weathering, deformation, and sedimentation).

9. Use models to explain how the flow of Earth's internal energy drives a cycling of matter between Earth's surface and deep interior causing plate movements (e.g., mid-ocean ridges, ocean trenches, volcanoes, earthquakes, mountains, rift valleys, volcanic islands).

10. Use research-based evidence to propose a scientific explanation regarding how the distribution of Earth's resources such as minerals, fossil fuels, and groundwater are the result of ongoing geoscience processes (e.g., past volcanic and hydrothermal activity, burial of organic sediments, active weathering of rock).

11. Develop and use models of Earth's interior composition to illustrate the resulting magnetic field (e.g., magnetic poles) and to explain its measureable effects (e.g., protection from cosmic radiation).

12. Integrate qualitative scientific and technical information (e.g., weather maps; diagrams; other visualizations, including radar and computer simulations) to support the claim that motions and complex interactions of air masses result in changes in weather conditions.
    a. Use various instruments (e.g., thermometers, barometers, anemometers, wet bulbs) to monitor local weather and examine weather patterns to predict various weather events, especially the impact of severe weather (e.g., fronts, hurricanes, tornados, blizzards, ice storms, droughts).

13. Use models (e.g., diagrams, maps, globes, digital representations) to explain how the rotation of Earth and unequal heating of its surface create patterns of atmospheric and oceanic circulation that determine regional climates.
    a. Use experiments to investigate how energy from the sun is distributed between Earth's surface and its atmosphere by convection and radiation (e.g., warmer water in a pan rising as cooler water sinks, warming one's hands by a campfire).

14. Analyze and interpret data (e.g., tables, graphs, maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; rates of human activities) to describe how various human activities (e.g., use of fossil fuels, creation of urban heat islands, agricultural practices) and natural processes (e.g., solar radiation, greenhouse effect, volcanic activity) may cause changes in local and global temperatures over time.

Earth and Human Activity

15. Analyze evidence (e.g., databases on human populations, rates of consumption of food and other natural resources) to explain how changes in human population, per capita consumption of natural resources, and other human activities (e.g., land use, resource development, water and air pollution, urbanization) affect Earth's systems.

16. Implement scientific principles to design processes for monitoring and minimizing human impact on the environment (e.g., water usage, including withdrawal of water from streams and aquifers or construction of dams and levees; land usage, including urban development, agriculture, or removal of wetlands; pollution of air, water, and land).*

GRADE 7
Life Science

Seventh-grade students experience a wide range of physical and psychological changes during this stage of development where peer perception and social interactions play major roles in life and learning. As students mature and become more independent, their sense of curiosity and discovery must be fostered as they are encouraged to develop the self-discipline necessary for mastery of concepts at a higher level.

A variety of instructional strategies and techniques is essential for guiding students in Grade 7. Teachers must provide opportunities for students to communicate and interact with peers in a collaborative setting to develop explanations and design solutions to real-world problems using scientific concepts and processes. At this stage where learning progresses from concrete to abstract and from knowledge to applications in science, the method of cooperative learning provides an excellent strategy for instruction and a unique opportunity for teachers to capitalize on students' need for peer interaction.

Individual content standards are organized according to the disciplinary core ideas in the Life Science domain. The first Life Science core idea, From Molecules to Organisms: Structures and Processes, concentrates on the structure and function of cells and their connections to organs and organ systems. The second core idea, Ecosystems: Interactions, Energy, and Dynamics, investigates the interactions between living organisms and between biotic and abiotic factors. The third core idea, Heredity: Inheritance and Variation of Traits, centers on explaining genetic variations, describing the results of genetic mutations, and evaluating impacts of genetic technologies. The fourth core idea, Unity and Diversity, examines the patterns of change in populations of organisms over a long period of time and the relationship between natural selection and the reproduction and survival of a population. The Engineering, Technology, and Applications of Science (ETS) core ideas may be integrated into the Physics content. The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

From Molecules to Organisms: Structures and Processes

1. Engage in argument from evidence to support claims of the cell theory.

2. Gather and synthesize information to explain how prokaryotic and eukaryotic cells differ in structure and function, including the methods of asexual and sexual reproduction.

3. Construct an explanation of the function (e.g., mitochondria releasing energy during cellular respiration) of specific cell structures (i.e., nucleus, cell membrane, cell wall, ribosomes, mitochondria, chloroplasts, and vacuoles) for maintaining a stable environment.

4. Construct models and representations of organ systems (e.g., circulatory, digestive, respiratory, muscular, skeletal, nervous) to demonstrate how multiple interacting organs and systems work together to accomplish specific functions.

Ecosystems: Interactions, Energy, and Dynamics

5. Examine the cycling of matter between abiotic and biotic parts of ecosystems to explain the flow of energy and the conservation of matter.
   a. Obtain, evaluate, and communicate information about how food is broken down through chemical reactions to create new molecules that support growth and/or release energy as it moves through an organism.
   b. Generate a scientific explanation based on evidence for the role of photosynthesis and cellular respiration in the cycling of matter and flow of energy into and out of organisms.

6. Analyze and interpret data to provide evidence regarding how resource availability impacts individual organisms as well as populations of organisms within an ecosystem.

7. Use empirical evidence from patterns and data to demonstrate how changes to physical or biological components of an ecosystem (e.g., deforestation, succession, drought, fire, disease, human activities, invasive species) can lead to shifts in populations.

8. Construct an explanation to predict patterns of interactions in different ecosystems in terms of the relationships between and among organisms (e.g., competition, predation, mutualism, commensalism, parasitism).

9. Engage in argument to defend the effectiveness of a design solution that maintains biodiversity and ecosystem services (e.g., using scientific, economic, and social considerations regarding purifying water, recycling nutrients, preventing soil erosion).

10. Use evidence and scientific reasoning to explain how characteristic animal behaviors (e.g., building nests to protect young from cold, herding to protect young from predators, attracting mates for breeding by producing special sounds and displaying colorful plumage, transferring pollen or seeds, creating conditions for seed germination and growth) and specialized plant structures (e.g., flower brightness, nectar, and odor attracting birds that transfer pollen; hard outer shells on seeds providing protection prior to germination) affect the probability of successful reproduction of both animals and plants.

11. Analyze and interpret data to predict how environmental conditions (e.g., weather, availability of nutrients, location) and genetic factors (e.g., selective breeding of cattle or crops) influence the growth of organisms (e.g., drought decreasing plant growth, adequate supply of nutrients for maintaining normal plant growth, identical plant seeds growing at different rates in different weather conditions, fish growing larger in large ponds than in small ponds).

Heredity: Inheritance and Variation of Traits

12. Construct and use models (e.g., monohybrid crosses using Punnett squares, diagrams, simulations) to explain that genetic variations between parent and offspring (e.g., different alleles, mutations) occur as a result of genetic differences in randomly inherited genes located on chromosomes and that additional variations may arise from alteration of genetic information.

13. Construct an explanation from evidence to describe how genetic mutations result in harmful, beneficial, or neutral effects to the structure and function of an organism.

14. Gather and synthesize information regarding the impact of technologies (e.g., hand pollination, selective breeding, genetic engineering, genetic modification, gene therapy) on the inheritance and/or appearance of desired traits in organisms.

Unity and Diversity

15. Analyze and interpret data for patterns of change in anatomical structures of organisms using the fossil record and the chronological order of fossil appearance in rock layers.

16. Construct an explanation based on evidence (e.g., cladogram, phylogenetic tree) for the anatomical similarities and differences among modern organisms and between modern and fossil organisms, including living fossils (e.g., alligator, horseshoe crab, nautilus, coelacanth).

17. Obtain and evaluate pictorial data to compare patterns in the embryological development across multiple species to identify relationships not evident in the adult anatomy.

18. Construct an explanation from evidence that natural selection acting over generations may lead to the predominance of certain traits that support successful survival and reproduction of a population and to the suppression of other traits.

GRADE 8
Physical Science

Students in eighth grade exhibit a wide range of learning styles and intellectual abilities. This diversity in development requires the implementation of a science curriculum that engages students in scientific inquiry. The classroom environment must provide opportunities for students to identify problems, ask questions, make observations, design solutions, and explore important scientific concepts through investigations. As students' curiosity and creativity flourish, teachers must design activities that encourage students to construct explanations based upon their own experiences and to use their creative abilities to devise solutions to real-world problems. Students engage in higher-level, abstract-thinking processes as they make connections between and among disciplines and become well-grounded in experiences. Students work in a variety of groups that foster collaboration among peers.

Grade 8 content standards are based upon the disciplinary core ideas in the Physical Science domain. The first core idea, Matter and Its Interactions, concentrates on the composition and properties of matter. The second core idea, Motion and Stability: Forces and Interactions, focuses on examining forces and predicting and developing explanations for changes in motion. The third core idea, Energy, involves the conservation of energy, energy transformations, and applications of energy to everyday life. The final core idea, Waves and Their Applications in Technologies for Information Transfer, examines types and properties of waves and the use of waves in communication devices. Integrated into the Physical Science content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to employ tools and materials to solve problems and to use representations to convey various design solutions. ETS standards are denoted with an asterisk (*).

Students will:

Matter and Its Interactions

1. Analyze patterns within the periodic table to construct models (e.g., molecular-level models, including drawings; computer representations) that illustrate the structure, composition, and characteristics of atoms and molecules.

2. Plan and carry out investigations to generate evidence supporting the claim that one pure substance can be distinguished from another based on characteristic properties.

3. Construct explanations based on evidence from investigations to differentiate among compounds, mixtures, and solutions.
    a. Collect and analyze information to illustrate how synthetic materials (e.g., medicine, food additives, alternative fuels, plastics) are derived from natural resources and how they impact society.

4. Design and conduct an experiment to determine changes in particle motion, temperature, and state of a pure substance when thermal energy is added to or removed from a system.

5. Observe and analyze characteristic properties of substances (e.g., odor, density, solubility, flammability, melting point, boiling point) before and after the substances combine to determine if a chemical reaction has occurred.

6. Create a model, diagram, or digital simulation to describe conservation of mass in a chemical reaction and explain the resulting differences between products and reactants.

7. Design, construct, and test a device (e.g., glow stick, hand warmer, hot or cold pack, thermal wrap) that either releases or absorbs thermal energy by chemical reactions (e.g., dissolving ammonium chloride or calcium chloride in water) and modify the device as needed based on criteria (e.g., amount/concentration, time, temperature).*

Motion and Stability: Forces and Interactions

8. Use Newton's first law to demonstrate and explain that an object is either at rest or moves at a constant velocity unless acted upon by an external force (e.g., model car on a table remaining at rest until pushed).

9. Use Newton's second law to demonstrate and explain how changes in an object's motion depend on the sum of the external forces on the object and the mass of the object (e.g., billiard balls moving when hit with a cue stick).

10. Use Newton's third law to design a model to demonstrate and explain the resulting motion of two colliding objects (e.g., two cars bumping into each other, a hammer hitting a nail).*

11. Plan and carry out investigations to evaluate how various factors (e.g., electric force produced between two charged objects at various positions; magnetic force produced by an electromagnet with varying number of wire turns, varying number or size of dry cells, and varying size of iron core) affect the strength of electric and magnetic forces.

12. Construct an argument from evidence explaining that fields exist between objects exerting forces on each other (e.g., interactions of magnets, electrically charged strips of tape, electrically charged pith balls, gravitational pull of the moon creating tides) even when the objects are not in contact.

Energy

13. Create and analyze graphical displays of data to illustrate the relationships of kinetic energy to the mass and speed of an object (e.g., riding a bicycle at different speeds, hitting a table tennis ball versus a golf ball, rolling similar toy cars with different masses down an incline).

14. Use models to construct an explanation of how a system of objects may contain varying types and amounts of potential energy (e.g., observing the movement of a roller coaster cart at various inclines, changing the tension in a rubber band, varying the number of batteries connected in a series, observing a balloon with static electrical charge being brought closer to a classmate's hair).

15. Analyze and interpret data from experiments to determine how various factors affect energy transfer as measured by temperature (e.g., comparing final water temperatures after different masses of ice melt in the same volume of water with the same initial temperature, observing the temperature change of samples of different materials with the same mass and the same material with different masses when adding a specific amount of energy).

16. Apply the law of conservation of energy to develop arguments supporting the claim that when the kinetic energy of an object changes, energy is transferred to or from the object (e.g., bowling ball hitting pins, brakes being applied to a car).

Waves and Their Applications in Technologies for Information Transfer

17. Create and manipulate a model of a simple wave to predict and describe the relationships between wave properties (e.g., frequency, amplitude, wavelength) and energy.
    a. Analyze and interpret data to illustrate an electromagnetic spectrum.

18. Use models to demonstrate how light and sound waves differ in how they are absorbed, reflected, and transmitted through different types of media.

19. Integrate qualitative information to explain that common communication devices (e.g., cellular telephones, radios, remote controls, Wi-Fi components, global positioning systems [GPS], wireless technology components) use electromagnetic waves to encode and transmit information.

GRADES 9-12
Overview

The high school science curriculum provides essential preparation for college and career readiness for all students in Grades 9-12. The courses are designed to enable students to attain scientific literacy of the disciplinary core ideas by engaging in science and engineering practices through increased rigor and sophistication to deepen their understanding of science content. By the end of high school, students should have an adequate scientific background to be active, informed citizens and to succeed in both the workplace and in postsecondary courses. Student expectations include the ability to formulate and pose scientific inquiries that establish what is known and what still needs to be understood, to conduct investigations based on well-developed hypotheses, to construct models to explain abstract concepts, to use appropriate tools to obtain numerical measurements that explain mathematical relationships, and to formulate their own explanations of scientific phenomena and be able to use these in problem solving. Finally, students should be able to obtain, assess, and communicate knowledge from scientific literature and construct and engage in evidence-based arguments.

The instructional environment of the science classroom should be student-centered, allowing individuals to participate in inquiry-based learning. All science courses in Grades 9-12 should include a laboratory-based component that encourages students to apply investigation and reasoning skills to develop explanations and propose solutions. Conceptual learning should be supported by computational and graphical representations, and students should be able to apply data analysis techniques, including calculating quantities involving significant figures, writing numbers in standard form and scientific notation, using the International System of Units (SI) as a form of measurement, and performing dimensional analysis. Teachers should incorporate literacy strategies (Appendix B) within the curriculum, including research using credible scientific sources and laboratory reports.

The 2015 *Alabama Course of Study: Science* contains the minimum required content for the Grades 9-12 courses of Physical Science, Biology, Chemistry, Physics, Human Anatomy and Physiology, Earth and Space Science, and Environmental Science. Content standards are integrated with scientific and engineering practices as well as crosscutting concepts that connect the knowledge discovered through observation of the natural world with concentrated themes that permeate throughout all science and engineering domains. This course of study specifies the required minimum subject content in a manner intended to balance a need for rigor in course offerings and consistency statewide with the need for flexibility in designing local course offerings. School systems are encouraged to expand the standards to address specific needs of the local student population and to utilize available resources while retaining the identified core as the foundation for all science courses. Current graduation requirements for students pursuing the Alabama High School Diploma, including the required science credits, are shown in Appendix B.

PHYSICAL SCIENCE

Physical Science is a conceptual, inquiry-based course that provides students with an investigation of the basic concepts of chemistry and physics. Students use evidence from their own investigations as well as the investigations of others to develop and refine knowledge of core ideas. Increased sophistication, both of their model-based explanations and the argumentation by which evidence and explanation are linked, is developed through language and mathematical skills appropriate to the individual student's cognitive ability level. The standards provide a depth of conceptual understanding that will adequately prepare them for college, career, and citizenship with an appropriate level of scientific literacy. Resources specific to the local area as well as external resources, including evidence-based literature found within scientific journals, should be used to extend and increase the complexity of the core ideas.

Content standards are organized according to the disciplinary core ideas for the Physical Science domain. The core idea, Matter and Its Interactions, deals with the substances and processes that encompass our universe on both microscopic and macroscopic levels. The second core idea, Motion and Stability: Forces and Interactions, includes the components of forces and motion, types of interactions, and stability/instability in physical systems. The third core idea, Energy, involves the conservation of energy, energy transformations, and applications of energy to everyday life. The fourth core idea, Waves and Their Applications in Technologies for Information Transfer, examines wave properties, electromagnetic radiation, and information technologies and instrumentation. Integrated within the disciplinary core ideas of Physical Science are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

Matter and Its Interactions

1. Use the periodic table as a model to predict the relative properties and trends (e.g., reactivity of metals; types of bonds formed, including ionic, covalent, and polar covalent; numbers of bonds formed; reactions with oxygen) of main group elements based on the patterns of valence electrons in atoms.

2. Plan and carry out investigations (e.g., squeezing a balloon, placing a balloon on ice) to identify the relationships that exist among the pressure, volume, density, and temperature of a confined gas.

3. Analyze and interpret data from a simple chemical reaction or combustion reaction involving main group elements.

4. Analyze and interpret data using acid-base indicators (e.g., color-changing markers, pH paper) to distinguish between acids and bases, including comparisons between strong and weak acids and bases.

5. Use mathematical representations to support and verify the claim that atoms, and therefore mass, are conserved during a simple chemical reaction.

6. Develop models to illustrate the concept of half-life for radioactive decay.
   a. Research and communicate information about types of naturally occurring radiation and their properties.
   b. Develop arguments for and against nuclear power generation compared to other types of power generation.

Motion and Stability: Forces and Interactions

7. Analyze and interpret data for one- and two-dimensional motion applying basic concepts of distance, displacement, speed, velocity, and acceleration (e.g., velocity versus time graphs, displacement versus time graphs, acceleration versus time graphs).

8. Apply Newton's laws to predict the motion of a system by constructing force diagrams that identify the external forces acting on the system, including friction (e.g., a book on a table, an object being pushed across a floor, an accelerating car).

9. Use mathematical equations (e.g., $(m_1v_1 + m_2v_2)_{\text{before}} = (m_1v_1 + m_2v_2)_{\text{after}}$) and diagrams to explain that the total momentum of a system of objects is conserved when there is no net external force on the system.
   a. Use the laws of conservation of mechanical energy and momentum to predict the result of one-dimensional elastic collisions.

10. Construct simple series and parallel circuits containing resistors and batteries and apply Ohm's law to solve typical problems demonstrating the effect of changing values of resistors and voltages.

Energy

11. Design and conduct investigations to verify the law of conservation of energy including transformations of potential energy, kinetic energy, thermal energy, and the effect of any work performed on or by the system.

12. Design, build, and test the ability of a device (e.g., Rube Goldberg devices, wind turbines, solar cells, solar ovens) to convert one form of energy into another form of energy.*

Waves and Their Applications in Technologies for Information Transfer

13. Use mathematical representations to demonstrate the relationships among wavelength, frequency, and speed of waves (e.g., the relation $v = \lambda f$) traveling in various media (e.g., electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, seismic waves traveling through Earth).

14. Propose and defend a hypothesis based on information gathered from published materials (e.g., trade books, magazines, Internet resources, videos) for and against various claims for the safety of electromagnetic radiation.

15. Obtain and communicate information from published materials to explain how transmitting and receiving devices (e.g., cellular telephones, medical-imaging technology, solar cells, wireless Internet, scanners, **So**und **N**avigation **a**nd **R**anging [SONAR]) use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

BIOLOGY

Biology is a required, inquiry-based course focused on providing all high school students with foundational life science content about the patterns, processes, and interactions among living organisms. The emphasis is on increased sophistication and rigor of a limited number of core ideas rather than on memorizing a breadth of factual content. Students use prior and new knowledge to build conceptual understandings based on evidence from their own and others' investigations. They use their own learning and experiences to support claims and engage in argument from evidence. The standards provide a depth of conceptual understanding to adequately prepare them for college, career, and citizenship with an appropriate level of scientific literacy. Resources specific to the local area as well as external resources, including evidenced-based literature found within scientific journals, should be used to extend and increase the complexity of the core ideas.

Content standards within this course are organized according to the disciplinary core ideas for the Life Science domain. The first core idea, From Molecules to Organisms: Structures and Processes, concentrates on the structure of cells and how their functions are necessary for supporting life, growth, behavior, and reproduction. The second core idea, Ecosystems: Interactions, Energy, and Dynamics, investigates the positive and negative interactions between living organisms and other biotic and abiotic factors. The third core idea, Heredity: Inheritance and Variation of Traits, centers on the formation of proteins that affect the trait expression, also known as the central dogma of molecular biology; the passing of distinguishing genetic information throughout generations; and how environmental factors and genetic errors can cause gene mutations. The fourth core idea, Unity and Diversity, examines the variation of traits within a population over a long period of time that results in diversity among organisms. Integrated within the disciplinary core ideas of Biology are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

From Molecules to Organisms: Structures and Processes

1. Use models to compare and contrast how the structural characteristics of carbohydrates, nucleic acids, proteins, and lipids define their function in organisms.

2. Obtain, evaluate, and communicate information to describe the function and diversity of organelles and structures in various types of cells (e.g., muscle cells having a large amount of mitochondria, plasmids in bacteria, chloroplasts in plant cells).

3. Formulate an evidence-based explanation regarding how the composition of deoxyribonucleic acid (DNA) determines the structural organization of proteins.
   a. Obtain and evaluate experiments of major scientists and communicate their contributions to the development of the structure of DNA and to the development of the central dogma of molecular biology.
   b. Obtain, evaluate, and communicate information that explains how advancements in genetic technology (e.g., Human Genome Project, **Enc**yclopedia **o**f **D**NA **E**lements [ENCODE] project, 1000 Genomes Project) have contributed to the understanding as to how a genetic change at the DNA level may affect proteins, and in turn, influence the appearance of traits.
   c. Obtain information to identify errors that occur during DNA replication (e.g., deletion, insertion, translocation, substitution, inversion, frame-shift, point mutations).

4. Develop and use models to explain the role of the cell cycle during growth and maintenance in multicellular organisms (e.g., normal growth and/or uncontrolled growth resulting in tumors).

5. Plan and carry out investigations to explain feedback mechanisms (e.g., sweating and shivering) and cellular processes (e.g., active and passive transport) that maintain homeostasis.
   a. Plan and carry out investigations to explain how the unique properties of water (e.g., polarity, cohesion, adhesion) are vital to maintaining homeostasis in organisms.

6. Analyze and interpret data from investigations to explain the role of products and reactants of photosynthesis and cellular respiration in the cycling of matter and the flow of energy.
   a. Plan and carry out investigations to explain the interactions among pigments, absorption of light, and reflection of light.

Ecosystems: Interactions, Energy, and Dynamics

7. Develop and use models to illustrate examples of ecological hierarchy levels, including biosphere, biome, ecosystem, community, population, and organism.

8. Develop and use models to describe the cycling of matter (e.g., carbon, nitrogen, water) and flow of energy (e.g., food chains, food webs, biomass pyramids, ten percent law) between abiotic and biotic factors in ecosystems.

9. Use mathematical comparisons and visual representations to support or refute explanations of factors that affect population growth (e.g., exponential, linear, logistic).

10. Construct an explanation and design a real-world solution to address changing conditions and ecological succession caused by density-dependent and/or density-independent factors.*

Heredity: Inheritance and Variation of Traits

11. Analyze and interpret data collected from probability calculations to explain the variation of expressed traits within a population.
    a. Use mathematics and computation to predict phenotypic and genotypic ratios and percentages by constructing Punnett squares, including using both homozygous and heterozygous allele pairs.
    b. Develop and use models to demonstrate codominance, incomplete dominance, and Mendel’s laws of segregation and independent assortment.
    c. Analyze and interpret data (e.g., pedigree charts, family and population studies) regarding Mendelian and complex genetic disorders (e.g., sickle-cell anemia, cystic fibrosis, type 2 diabetes) to determine patterns of genetic inheritance and disease risks from both genetic and environmental factors.

12. Develop and use a model to analyze the structure of chromosomes and how new genetic combinations occur through the process of meiosis.
    a. Analyze data to draw conclusions about genetic disorders caused by errors in meiosis (e.g., Down syndrome, Turner syndrome).

Unity and Diversity

13. Obtain, evaluate, and communicate information to explain how organisms are classified by physical characteristics, organized into levels of taxonomy, and identified by binomial nomenclature (e.g., taxonomic classification, dichotomous keys).
    a. Engage in argument to justify the grouping of viruses in a category separate from living things.

14. Analyze and interpret data to evaluate adaptations resulting from natural and artificial selection that may cause changes in populations over time (e.g., antibiotic-resistant bacteria, beak types, peppered moths, pest-resistant crops).

15. Engage in argument from evidence (e.g., mathematical models such as distribution graphs) to explain how the diversity of organisms is affected by overpopulation of species, variation due to genetic mutations, and competition for limited resources.

16. Analyze scientific evidence (e.g., DNA, fossil records, cladograms, biogeography) to support hypotheses of common ancestry and biological evolution.

CHEMISTRY

Chemistry is an elective course that provides students with an investigation of empirical concepts central to biology, earth science, environmental science, and physiology. Chemistry encompasses both qualitative and quantitative ideas derived using the scientific process. By its very nature, the study of chemistry encourages an inquiry-based approach to understanding the substances and processes that explain our world as well as ourselves. Using the practices of science, core ideas are explored in greater detail and refined with increased sophistication and rigor based upon knowledge acquired in earlier grades. Students use the academic language of science in context to communicate claims, evidence, and reasoning for chemical phenomena. The course provides high school students with more in-depth investigations on the properties and interactions of matter. Students acquire prerequisite skills for postsecondary studies and careers in science, technology, engineering, and mathematics (STEM) fields. Additional external resources, including evidence-based research found in scientific journals, should be utilized to provide students with a broad scientific experience that will adequately prepare them for college, career, and citizenship.

Content standards within this course are organized according to two of the core ideas for Physical Science. The first core idea, Matter and Its Interactions, deals with the substances and processes that encompass our universe on both microscopic and macroscopic levels. The second core idea, Motion and Stability: Forces and Interactions, concentrates on forces and motion, types of interactions, and stability and instability in chemical systems. The third core idea, Energy, involves the conservation of energy, energy transformations, and applications of energy to everyday life. Integrated within the disciplinary core ideas of Chemistry are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

Matter and Its Interactions

1. Obtain and communicate information from historical experiments (e.g., work by Mendeleev and Moseley, Rutherford’s gold foil experiment, Thomson’s cathode ray experiment, Millikan’s oil drop experiment, Bohr’s interpretation of bright line spectra) to determine the structure and function of an atom and to analyze the patterns represented in the periodic table.

2. Develop and use models of atomic nuclei to explain why the abundance-weighted average of isotopes of an element yields the published atomic mass.

3. Use the periodic table as a systematic representation to predict properties of elements based on their valence electron arrangement.
    a. Analyze data such as physical properties to explain periodic trends of the elements, including metal/nonmetal/metalloid behavior, electrical/heat conductivity, electronegativity and electron affinity, ionization energy, and atomic-covalent/ionic radii and how they relate to position in the periodic table.
    b. Develop and use models (e.g., Lewis dot, 3-D ball-and-stick, space-filling, valence-shell electron-pair repulsion [VSEPR]) to predict the type of bonding and shape of simple compounds.
    c. Use the periodic table as a model to derive formulas and names of ionic and covalent compounds.

4. Plan and conduct an investigation to classify properties of matter as intensive (e.g., density, viscosity, specific heat, melting point, boiling point) or extensive (e.g., mass, volume, heat) and demonstrate how intensive properties can be used to identify a compound.

5. Plan and conduct investigations to demonstrate different types of simple chemical reactions based on valence electron arrangements of the reactants and determine the quantity of products and reactants.
    a. Use mathematics and computational thinking to represent the ratio of reactants and products in terms of masses, molecules and moles.
    b. Use mathematics and computational thinking to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

6. Use mathematics and computational thinking to express the concentrations of solutions quantitatively using molarity.
    a. Develop and use models to explain how solutes are dissolved in solvents.
    b. Analyze and interpret data to explain effects of temperature on the solubility of solid, liquid, and gaseous solutes in a solvent and the effects of pressure on the solubility of gaseous solutes.
    c. Design and conduct experiments to test the conductivity of common ionic and covalent substances in a solution.
    d. Use the concept of pH as a model to predict the relative properties of strong, weak, concentrated, and dilute acids and bases (e.g., Arrhenius and Brønsted-Lowry acids and bases).

7. Plan and carry out investigations to explain the behavior of ideal gases in terms of pressure, volume, temperature, and number of particles.
    a. Use mathematics to describe the relationships among pressure, temperature, and volume of an enclosed gas when only the amount of gas is constant.
    b. Use mathematical and computational thinking based on the ideal gas law to determine molar quantities.

8. Refine the design of a given chemical system to illustrate how LeChâtelier’s principle affects a dynamic chemical equilibrium when subjected to an outside stress (e.g., heating and cooling a saturated sugar-water solution).*

Motion and Stability: Forces and Interactions

9. Analyze and interpret data (e.g., melting point, boiling point, solubility, phase-change diagrams) to compare the strength of intermolecular forces and how these forces affect physical properties and changes.

Energy

10. Plan and conduct experiments that demonstrate how changes in a system (e.g., phase changes, pressure of a gas) validate the kinetic molecular theory.
    a. Develop a model to explain the relationship between the average kinetic energy of the particles in a substance and the temperature of the substance (e.g., no kinetic energy equaling absolute zero [0K or -273.15ºC]).

11. Construct an explanation that describes how the release or absorption of energy from a system depends upon changes in the components of the system.
    a. Develop a model to illustrate how the changes in total bond energy determine whether a chemical reaction is endothermic or exothermic.
    b. Plan and conduct an investigation that demonstrates the transfer of thermal energy in a closed system (e.g., using heat capacities of two components of differing temperatures).

PHYSICS

Physics is an elective course focused on providing high school students with foundational content regarding properties of physical matter, physical quantities, and their interactions. The course provides the required science background preparation for students who plan to pursue postsecondary studies and careers in science, technology, engineering, and mathematics (STEM) fields. Using the practices of science, core ideas are explored and developed in more detail and refined with increased sophistication and rigor based upon knowledge acquired in earlier grades. Students learn through investigation and analysis of data and from their own experiments and those that cannot be undertaken in a science classroom. The academic language of physics is used in context to communicate claims, evidence, and reasoning for phenomena and to engage in argument from evidence to justify and defend claims. Students take part in active learning involving authentic investigations and engineering design processes. The Physics course provides a rich learning context for acquiring knowledge of the practices, core ideas, and crosscutting concepts that lead to the development of critical-thinking, problem-solving, and information literacy skills. Additional external resources, including evidence-based literature found within scientific journals, research, and other facilities, should be utilized to provide students with science experiences that will adequately prepare them for college, career, and citizenship.

Content standards within this course are organized according to the core ideas for Physical Science. The first core idea, Motion and Stability: Forces and Interactions, concentrates on forces and motion, types of interactions, and stability and instability in physical systems. The second core idea, Energy, investigates conservation of energy, energy transformations, and applications of energy to everyday life. The final core idea, Waves and Their Applications in Technologies for Information Transfer, examines wave properties, electromagnetic radiation, and information technologies and instrumentation. The Engineering, Technology, and Applications of Science (ETS) core ideas may be integrated into the Physics content. The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

Motion and Stability: Forces and Interactions

1. Investigate and analyze, based on evidence obtained through observation or experimental design, the motion of an object using both graphical and mathematical models (e.g., creating or interpreting graphs of position, velocity, and acceleration versus time graphs for one- and two-dimensional motion; solving problems using kinematic equations for the case of constant acceleration) that may include descriptors such as position, distance traveled, displacement, speed, velocity, and acceleration.

2. Identify external forces acting on a system and apply Newton's laws graphically by using models such as free-body diagrams to explain how the motion of an object is affected, ranging from simple to complex, and including circular motion.
   a. Use mathematical computations to derive simple equations of motion for various systems using Newton's second law.
   b. Use mathematical computations to explain the nature of forces (e.g., tension, friction, normal) related to Newton's second and third laws.

3. Evaluate qualitatively and quantitatively the relationship between the force acting on an object, the time of interaction, and the change in momentum using the impulse-momentum theorem.

4. Identify and analyze forces responsible for changes in rotational motion and develop an understanding of the effect of rotational inertia on the motion of a rotating object (e.g., merry-go-round, spinning toy, spinning figure skater, stellar collapse [supernova], rapidly spinning pulsar).

Energy

5. Construct models that illustrate how energy is related to work performed on or by an object and explain how different forms of energy are transformed from one form to another (e.g., distinguishing between kinetic, potential, and other forms of energy such as thermal and sound; applying both the work-energy theorem and the law of conservation of energy to systems such as roller coasters, falling objects, and spring-mass systems; discussing the effect of frictional forces on energy conservation and how it affects the motion of an object).

6. Investigate collisions, both elastic and inelastic, to evaluate the effects on momentum and energy conservation.

7. Plan and carry out investigations to provide evidence that the first and second laws of thermodynamics relate work and heat transfers to the change in internal energy of a system with limits on the ability to do useful work (e.g., heat engine transforming heat at high temperature into mechanical energy and low-temperature waste heat, refrigerator absorbing heat from the cold reservoir and giving off heat to the hot reservoir with work being done).
    a. Develop models to illustrate methods of heat transfer by conduction (e.g., an ice cube in water), convection (e.g., currents that transfer heat from the interior up to the surface), and radiation (e.g., an object in sunlight).
    b. Engage in argument from evidence regarding how the second law of thermodynamics applies to the entropy of open and closed systems.

Waves and Their Applications in Technologies for Information Transfer

8. Investigate the nature of wave behavior to illustrate the concept of the superposition principle responsible for wave patterns, constructive and destructive interference, and standing waves (e.g., organ pipes, tuned exhaust systems).
    a. Predict and explore how wave behavior is applied to scientific phenomena such as the Doppler effect and **So**und **N**avigation **a**nd **R**anging (SONAR).

9. Obtain and evaluate information regarding technical devices to describe wave propagation of electromagnetic radiation and compare it to sound propagation. (e.g., wireless telephones, magnetic resonance imaging [MRI], microwave systems, **Ra**dio **D**etection **a**nd **R**anging [RADAR], SONAR, ultrasound).

10. Plan and carry out investigations that evaluate the mathematical explanations of light as related to optical systems (e.g., reflection, refraction, diffraction, intensity, polarization, Snell's law, the inverse square law).

11. Develop and use models to illustrate electric and magnetic fields, including how each is created (e.g., charging by either conduction or induction and polarizing; sketching field lines for situations such as point charges, a charged straight wire, or a current carrying wires such as solenoids; calculating the forces due to Coulomb's laws), and predict the motion of charged particles in each field and the energy required to move a charge between two points in each field.

12. Use the principles of Ohm's and Kirchhoff's laws to design, construct, and analyze combination circuits using typical components (e.g., resistors, capacitors, diodes, sources of power).

HUMAN ANATOMY AND PHYSIOLOGY

The Human Anatomy and Physiology course is designed to address the structure and function of human body systems from the cellular level to the organism level in an approach that complements the natural curiosity of high school students. The course addresses the interactions within and between systems that maintain homeostasis in an organism. It is designed for students who have an interest in learning how the human body works and for those interested in health-related science, technology, engineering, and mathematics (STEM) careers. As students engage in the study of human body systems, they are encouraged to apply the knowledge and processes of science to personally relevant issues, including how personal choices, environmental factors, and genetic factors affect the human body.

The Human Anatomy and Physiology standards provide a depth of conceptual understanding to adequately prepare students for college, career, and citizenship with an appropriate level of scientific literacy. This course encourages critical thinking, the integration of technology, and the application of knowledge and skills to solve problems. An important component of this course is a safe laboratory setting where students participate in active learning to illustrate scientific concepts that incorporate activities such as histological studies, dissections, urinalysis and blood-testing simulations, and computer-based electrocardiography. Students are expected to use clear and accurate academic language, keep detailed records, make oral and written presentations, and defend claims based on evidence from their own and others' scientific investigations.

Content standards within this course are organized according to one of the core ideas of Life Science, From Molecules to Organisms: Structures and Processes. This core idea is explored more extensively within the specific context of the anatomy and physiology of human body systems. Content standards focus on the growth and development of human body systems as well as on the structure and function of these systems from the cellular level to the organism level. Integrated within the discipline of Human Anatomy and Physiology are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

From Molecules to Organisms: Structures and Processes

1. Develop and use models and appropriate terminology to identify regions, directions, planes, and cavities in the human body to locate organs and systems.

2. Analyze characteristics of tissue types (e.g., epithelial tissue) and construct an explanation of how the chemical and structural organizations of the cells that form these tissues are specialized to conduct the function of that tissue (e.g., lining, protecting).

3. Obtain and communicate information to explain the integumentary system's structure and function, including layers and accessories of skin and types of membranes.
   a. Analyze the effects of pathological conditions (e.g., burns, skin cancer, bacterial and viral infections, chemical dermatitis) to determine the body's attempt to maintain homeostasis.

4. Use models to identify the structure and function of the skeletal system (e.g., classification of bones by shape, classification of joints and the appendicular and axial skeletons).
    a. Obtain and communicate information to demonstrate understanding of the growth and development of the skeletal system (e.g., bone growth and remodeling).
    b. Obtain and communicate information to demonstrate understanding of the pathology of the skeletal system (e.g., types of bone fractures and their treatment, osteoporosis, rickets, other bone diseases).

5. Develop and use models to illustrate the anatomy of the muscular system, including muscle locations and groups, actions, origins and insertions.
    a. Plan and conduct investigations to explain the physiology of the muscular system (e.g., muscle contraction/relaxation, muscle fatigue, muscle tone), including pathological conditions (e.g., muscular dystrophy).

6. Obtain, evaluate, and communicate information regarding how the central nervous system and peripheral nervous system interrelate, including how these systems affect all other body systems to maintain homeostasis.
    a. Use scientific evidence to evaluate the effects of pathology on the nervous system (e.g., Parkinson's disease, Alzheimer's disease, cerebral palsy, head trauma) and argue possible prevention and treatment options.
    b. Design a medication to treat a disorder associated with neurotransmission, including mode of entry into the body, form of medication, and desired effects.*

7. Use models to determine the relationship between the structures in and functions of the cardiovascular system (e.g., components of blood, blood circulation through the heart and systems of the body, ABO blood groups, anatomy of the heart, types of blood vessels).
    a. Engage in argument from evidence regarding possible prevention and treatment options related to the pathology of the cardiovascular system (e.g., myocardial infarction, mitral valve prolapse, varicose veins, arteriosclerosis, anemia, high blood pressure).
    b. Design and carry out an experiment to test various conditions that affect the heart (e.g., heart rate, blood pressure, electrocardiogram [ECG] output.)

8. Communicate scientific information to explain the relationship between the structures and functions, both mechanical (e.g., chewing, churning in stomach) and chemical (e.g., enzymes, hydrochloric acid [HCl] in stomach), of the digestive system, including the accessory organs (e.g., salivary glands, pancreas).
    a. Obtain and communicate information to demonstrate an understanding of the disorders of the digestive system (e.g., ulcers, Crohn's disease, diverticulitis).

9. Develop and use a model to explain how the organs of the respiratory system function.
    a. Engage in argument from evidence describing how environmental (e.g., cigarette smoke, polluted air) and genetic factors may affect the respiratory system, possibly leading to pathological conditions (e.g., cystic fibrosis).

10. Obtain, evaluate, and communicate information to differentiate between the male and female reproductive systems, including pathological conditions that affect each.
    a. Use models to demonstrate what occurs in fetal development at each stage of pregnancy.

11. Use models to differentiate the structures of the urinary system and to describe their functions.
    a. Analyze and interpret data related to the urinary system to show the relationship between homeostatic imbalances and disease (e.g., kidney stones, effects of pH imbalances).

12. Obtain and communicate information to explain the lymphatic organs and their structure and function.
    a. Develop and use a model to explain the body's lines of defense and immunity.
    b. Obtain and communicate information to demonstrate an understanding of the disorders of the immune system (e.g., acquired immunodeficiency syndrome [AIDS], severe combined immunodeficiency [SCID]).

13. Obtain, evaluate, and communicate information to support the claim that the endocrine glands secrete hormones that help the body maintain homeostasis through feedback loops.
    a. Analyze the effects of pathological conditions (e.g., pituitary dwarfism, Addison's disease, diabetes mellitus) caused by imbalance of the hormones of the endocrine glands.

EARTH AND SPACE SCIENCE

The Earth and Space Science course is highly recommended for all high school students. Content focuses on a comprehensive application of all disciplines of science, based on the biologically active nature of our ever-changing planet and the integration of systems that constantly evolve. In an effort to encourage students to pursue careers in the fields of science, technology, engineering, and mathematics (STEM), this course incorporates the scientific and engineering practices that reflect the scientific processes used by scientists. The scientific and engineering practices are implemented through a student-centered, laboratory-intensive, collaborative classroom environment.

The Earth and Space Science standards provide a depth of conceptual understanding to adequately prepare students for college, career, and citizenship with an appropriate level of scientific literacy. Resources specific to the local area as well as external resources, including evidence-based literature found within scientific journals, should be used to extend and increase the complexity of the core ideas.

The foundation of the course is taken from two disciplinary core ideas in the Earth and Space Science domain. The first core idea, Earth's Place in the Universe, addresses the concepts of the universe and its stars, Earth and the solar system, and the history of planet Earth. The second core idea, Earth's Systems, examines Earth's materials and systems, plate tectonics and large-scale system interactions, the roles of water in Earth's surface processes, weather and climate, and biogeology. Integrated within the disciplinary core ideas of Earth and Space Science are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

Earth's Place in the Universe

1. Develop and use models to illustrate the lifespan of the sun, including energy released during nuclear fusion that eventually reaches Earth through radiation.

2. Engage in argument from evidence to compare various theories for the formation and changing nature of the universe and our solar system (e.g., Big Bang Theory, Hubble's law, steady state theory, light spectra, motion of distant galaxies, composition of matter in the universe).

3. Evaluate and communicate scientific information (e.g., Hertzsprung-Russell diagram) in reference to the life cycle of stars using data of both atomic emission and absorption spectra of stars to make inferences about the presence of certain elements.

4. Apply mathematics and computational thinking in reference to Kepler's laws, Newton's laws of motion, and Newton's gravitational laws to predict the orbital motion of natural and man-made objects in the solar system.

5. Use mathematics to explain the relationship of the seasons to the tilt of Earth's axis (e.g., zenith angle, solar angle, surface area) and its revolution about the sun, addressing intensity and distribution of sunlight on Earth's surface.

6. Obtain and evaluate information about Copernicus, Galileo, Kepler, Newton, and Einstein to communicate how their findings challenged conventional thinking and allowed for academic advancements and space exploration.

Earth's Systems

7. Analyze and interpret evidence regarding the theory of plate tectonics, including geologic activity along plate boundaries and magnetic patterns in undersea rocks, to explain the ages and movements of continental and oceanic crusts.

8. Develop a time scale model of Earth's biological and geological history to establish relative and absolute age of major events in Earth's history (e.g., radiometric dating, models of geologic cross sections, sedimentary layering, fossilization, early life forms, folding, faulting, igneous intrusions).

9. Obtain, evaluate, and communicate information to explain how constructive and destructive processes (e.g., weathering, erosion, volcanism, orogeny, plate tectonics, tectonic uplift) shape Earth's land features (e.g., mountains, valleys, plateaus) and sea features (e.g., trenches, ridges, seamounts).

10. Construct an explanation from evidence for the processes that generate the transformation of rocks in Earth's crust, including chemical composition of minerals and characteristics of sedimentary, igneous, and metamorphic rocks.

11. Obtain and communicate information about significant geologic characteristics (e.g., types of rocks and geologic ages, earthquake zones, sinkholes, caves, abundant fossil fauna, mineral and energy resources) that impact life in Alabama and the southeastern United States.

12. Develop a model of Earth's layers using available evidence to explain the role of thermal convection in the movement of Earth's materials (e.g., seismic waves, movement of tectonic plates).

13. Analyze and interpret data of interactions between the hydrologic and rock cycles to explain the mechanical impacts (e.g., stream transportation and deposition, erosion, frost-wedging) and chemical impacts (e.g., oxidation, hydrolysis, carbonation) of Earth materials by water's properties.

14. Construct explanations from evidence to describe how changes in the flow of energy through Earth's systems (e.g., volcanic eruptions, solar output, ocean circulation, surface temperatures, precipitation patterns, glacial ice volumes, sea levels, Coriolis effect) impact the climate.

15. Obtain, evaluate, and communicate information to verify that weather (e.g., temperature, relative humidity, air pressure, dew point, adiabatic cooling, condensation, precipitation, winds, ocean currents, barometric pressure, wind velocity) is influenced by energy transfer within and among the atmosphere, lithosphere, biosphere, and hydrosphere.
    a. Analyze patterns in weather data to predict various systems, including fronts and severe storms.
    b. Use maps and other visualizations to analyze large data sets that illustrate the frequency, magnitude, and resulting damage from severe weather events in order to predict the likelihood and severity of future events.

ENVIRONMENTAL SCIENCE

Environmental Science is a course that introduces students to a broad view of the biosphere and the physical parameters that affect it. The course incorporates the scientific and engineering practices reflecting the scientific processes used in science, technology, engineering, and mathematics (STEM) fields. The scientific and engineering practices are implemented through a student-centered and collaborative classroom environment that is laboratory-intensive and includes field investigations and case studies.

Core ideas are explored and developed in more detail and refined with increased sophistication and rigor based upon knowledge gained in earlier grades. Students learn by constructing explanations from evidence acquired through analysis and interpretation of data from laboratory investigations, field investigations, and case studies. Students integrate and evaluate multiple sources of authentic information to address issues or suggest possible solutions to problems in the environment based on current findings. The academic language of the core idea is used in context to communicate claims, evidence, and reasoning for phenomena and to engage in argument from evidence to justify and defend claims. Students are encouraged to use creativity in designing engineering solutions to solve various problems affecting Earth and its environment.

The Environmental Science content standards provide a depth of conceptual understanding to adequately prepare students for college, career, and citizenship with an appropriate level of scientific literacy. The foundation of the course is based upon the disciplinary core idea, Earth and Human Activity. Core component areas of study include natural resources, natural hazards, human impacts on Earth systems, and global climate change. Integrated within the disciplinary core ideas of Environmental Science are the Engineering, Technology, and Applications of Science (ETS) core ideas, which are denoted with an asterisk (*). The ETS core ideas require students to use tools and materials to solve simple problems and to use representations to convey design solutions to a problem and determine which is most appropriate.

Students will:

Earth and Human Activity

1. Investigate and analyze the use of nonrenewable energy sources (e.g., fossil fuels, nuclear, natural gas) and renewable energy sources (e.g., solar, wind, hydroelectric, geothermal) and propose solutions for their impact on the environment.

2. Use models to illustrate and communicate the role of photosynthesis and cellular respiration as carbon cycles through the biosphere, atmosphere, hydrosphere, and geosphere.

3. Use mathematics and graphic models to compare factors affecting biodiversity and populations in ecosystems.

4. Engage in argument from evidence to evaluate how biological or physical changes within ecosystems (e.g., ecological succession, seasonal flooding, volcanic eruptions) affect the number and types of organisms, and that changing conditions may result in a new or altered ecosystem.

5. Engage in argument from evidence to compare how individual versus group behavior (e.g., flocking; cooperative behaviors such as hunting, migrating, and swarming) may affect a species' chance to survive and reproduce over time.

6. Obtain, evaluate, and communicate information to describe how human activity may affect biodiversity and genetic variation of organisms, including threatened and endangered species.

7. Analyze and interpret data to investigate how a single change on Earth's surface may cause changes to other Earth systems (e.g., loss of ground vegetation causing an increase in water runoff and soil erosion).

8. Engage in an evidence-based argument to explain how over time Earth's systems affect the biosphere and the biosphere affects Earth's systems (e.g., microbial life increasing the formation of soil; corals creating reefs that alter patterns of erosion and deposition along coastlines).

9. Develop and use models to trace the flow of water, nitrogen, and phosphorus through the hydrosphere, atmosphere, geosphere, and biosphere.

10. Design solutions for protection of natural water resources (e.g., bioassessment, methods of water treatment and conservation) considering properties, uses, and pollutants (e.g., eutrophication, industrial effluents, agricultural runoffs, point and nonpoint pollution resources).*

11. Engage in argument from evidence to defend how coastal, marine, and freshwater sources (e.g., estuaries, marshes, tidal pools, wetlands, beaches, inlets, rivers, lakes, oceans, coral reefs) support biodiversity, economic stability, and human recreation.

12. Analyze and interpret data and climate models to predict how global or regional climate change can affect Earth's systems (e.g., precipitation and temperature and their associated impacts on sea level, glacial ice volumes, and atmosphere and ocean composition).

13. Obtain, evaluate, and communicate information based on evidence to explain how key natural resources (e.g., water sources, fertile soils, concentrations of minerals and fossil fuels), natural hazards, and climate changes influence human activity (e.g., mass migrations).

14. Analyze cost-benefit ratios of competing solutions for developing, conserving, managing, recycling, and reusing energy and mineral resources to minimize impacts in natural systems (e.g., determining best practices for agricultural soil use, mining for coal, and exploring for petroleum and natural gas sources).*

15. Construct an explanation based on evidence to determine the relationships among management of natural resources, human sustainability, and biodiversity (e.g., resources, waste management, per capita consumption, agricultural efficiency, urban planning).

16. Obtain and evaluate information from published results of scientific computational models to illustrate the relationships among Earth's systems and how these relationships may be impacted by human activity (e.g., effects of an increase in atmospheric carbon dioxide on photosynthetic biomass, effect of ocean acidification on marine populations).

17. Obtain, evaluate, and communicate geological and biological information to determine the types of organisms that live in major biomes.
    a. Analyze and interpret data collected through geographic research and field investigations (e.g., relief, topographic, and physiographic maps; rivers; forest types; watersheds) to describe the biodiversity by region for the state of Alabama (e.g., terrestrial, freshwater, marine, endangered, invasive).

LITERACY STANDARDS FOR GRADES 6-12: HISTORY/SOCIAL STUDIES, SCIENCE, AND TECHNICAL SUBJECTS

College- and Career-Readiness Anchor Standards for Reading

The Grades 6-12 standards on the following pages define what students should understand and be able to do by the end of each grade span. They correspond to the College- and Career-Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze how and why individuals, events, or ideas develop and interact over the course of a text.

Craft and Structure

4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section, chapter, scene, or stanza) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas

7. Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.
8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range of Reading and Level of Text Complexity

10. Read and comprehend complex literary and informational texts independently and proficiently.

Reading Standards for Literacy in Science and Technical Subjects 6-12

Grades 6-8 Students:	Grades 9-10 Students:	Grades 11-12 Students:
Key Ideas and Details		
1. Cite specific textual evidence to support analysis of science and technical texts.	1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.	1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.	2. Determine the central ideas or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.	2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.	3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.	3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
Craft and Structure		
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *Grades 6-8 texts and topics.*	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *Grades 9-10 texts and topics.*	4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *Grades 11-12 texts and topics.*
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.	5. Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).	5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.	6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
Integration of Knowledge and Ideas		
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).	7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.	7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.	8. Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.	8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
9. Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.	9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.	9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
Range of Reading and Level of Text Complexity		
10. By the end of Grade 8, read and comprehend science/technical texts in the Grades 6-8 text complexity band independently and proficiently.	10. By the end of Grade 10, read and comprehend science/technical texts in the Grades 9-10 text complexity band independently and proficiently.	10. By the end of Grade 12, read and comprehend science/technical texts in the Grades 11-CCR text complexity band independently and proficiently.

College- and Career-Readiness Anchor Standards for Writing

The Grades 6-12 standards on the following pages define what students should understand and be able to do by the end of each grade span. They correspond to the College- and Career-Readiness (CCR) anchor standards below by number. The CCR and grade-specific standards are necessary complements—the former providing broad standards, the latter providing additional specificity—that together define the skills and understandings that all students must demonstrate.

Text Types and Purposes*

1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence.
2. Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.
3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

Production and Distribution of Writing

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

Research to Build and Present Knowledge

7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.
9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

Range of Writing

10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

*These broad types of writing include many subgenres.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12

The standards below begin at Grade 6; standards for K-5 writing in history/social studies, science, and technical subjects are integrated into the K-5 writing standards. The CCR anchor standards and high school standards in literacy work in tandem to define college- and career-readiness expectations—the former providing broad standards, the latter providing additional specificity.

Grades 6-8 Students:	Grades 9-10 Students:	Grades 11-12 Students:
Text Types and Purposes		
1. Write arguments focused on *discipline-specific content*. a. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically. b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources. c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence. d. Establish and maintain a formal style. e. Provide a concluding statement or section that follows from and supports the argument presented.	1. Write arguments focused on *discipline-specific content*. a. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns. c. Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented.	1. Write arguments focused on *discipline-specific content*. a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence. b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases. c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims. d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. e. Provide a concluding statement or section that follows from or supports the argument presented.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12 (Continued)

Grades 6-8 Students:	Grades 9-10 Students:	Grades 11-12 Students:
Text Types and Purposes (Continued)		
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic clearly, previewing what is to follow; organize ideas, concepts, and information into broader categories as appropriate to achieving purpose; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. c. Use appropriate and varied transitions to create cohesion and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to inform about or explain the topic. e. Establish and maintain a formal style and objective tone. f. Provide a concluding statement or section that follows from and supports the information or explanation presented.	2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic with well-chosen, relevant, sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts. d. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).	2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic. c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts. d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers. e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).
3. (See note; not applicable as a separate requirement)	3. (See note; not applicable as a separate requirement)	3. (See note; not applicable as a separate requirement)

Note: Students' narrative skills continue to grow in these grades. The standards require that students be able to incorporate narrative elements effectively into arguments and informative/explanatory texts. In history/social studies, students must be able to incorporate narrative accounts into their analyses of individuals or events of historical import. In science and technical subjects, students must be able to write precise enough descriptions of the step-by-step procedures they use in their investigations or technical work so others can replicate them and (possibly) reach the same results.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12 (Continued)

Grades 6-8 Students:	Grades 9-10 Students:	Grades 11-12 Students:
Production and Distribution of Writing		
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.	4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.	5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.	5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
6. Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.	6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.	6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
Research to Build and Present Knowledge		
7. Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.	7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.	8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.	8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research.	9. Draw evidence from informational texts to support analysis, reflection, and research.	9. Draw evidence from informational texts to support analysis, reflection, and research.
Range of Writing		
10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.	10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

ALABAMA HIGH SCHOOL GRADUATION REQUIREMENTS

(Alabama Administrative Code 290-3-1-02(8) and (8)(a))

Effective for students in the ninth grade in the 2013-2014 school year, all students shall earn the required credits for the Alabama High School Diploma. A local board of education may establish requirements for receipt of diplomas and endorsements, but any diploma or endorsement shall include the requirements of the Alabama High School Diploma. The Alabama courses of study shall be followed in determining minimum required content in each discipline.

COURSE REQUIREMENTS

English Language Arts	**Four credits to include:**	**Credits**
	English 9	**1**
	English 10	**1**
	English 11	**1**
	English 12	**1**
	Equivalent/substitute options may include: Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses	
	English Language Arts Total Credits	**4**
Mathematics	**Three credits to include:**	**Credits**
	Algebra I or its equivalent/substitute	**1**
	Geometry or its equivalent/substitute	**1**
	Algebra II w/Trigonometry or Algebra II, or its equivalent/substitute	**1**
	Equivalent/substitute options may include: *Career and Technical Education*/Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses.	
	One credit from:	
	Alabama Course of Study for Mathematics or equivalent/substitute courses from *Career and Technical Education*/Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses.	**1**
	Mathematics Total Credits	**4**
Science	**Two credits to include:**	**Credits**
	Biology	**1**
	A physical science (Chemistry, Physics, Physical Science)	**1**
	Equivalent/substitute options may include: *Career and Technical Education*/Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses.	
	Two credits from:	
	Alabama Course of Study for Science or *equivalent/substitute courses from Career and Technical Education/Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses*	**2**
	Science Total Credits	**4**
Social Studies*	**Four credits to include:**	**Credits**
	World History	**1**
	United States History I	**1**
	United States History II	**1**
	United States Government	**0.5**
	Economics	**0.5**
	Equivalent /substitute options may include: Advanced Placement/International Baccalaureate/postsecondary courses/SDE approved courses	
	Social Studies Total Credits	**4**
Physical Education	Lifelong Individualized Fitness Education (LIFE) or one JROTC Credit	**1**
Health Education		**0.5**
Career Preparedness		**1**
Career and Technical Education and/or Foreign Language and/or Arts Education		**3**
Electives		**2.5**
	Total Credits	**24**

GUIDELINES AND SUGGESTIONS FOR LOCAL TIME REQUIREMENTS AND HOMEWORK

Total Instructional Time

The total instructional time of each school day in all schools and at all grade levels shall be not less than 6 hours or 360 minutes, exclusive of lunch periods, recess, or time used for changing classes (*Code of Alabama*, 1975, §16-1-1).

Suggested Time Allotments for Grades 1-6

The allocations below are based on considerations of a balanced educational program for Grades 1-6. Local school systems are encouraged to develop a general plan for scheduling that supports interdisciplinary instruction. Remedial and/or enrichment activities should be a part of the time schedule for the specific subject area.

Subject Area	Grades 1-3	Grades 4-6
Language Arts	150 minutes daily	120 minutes daily
Mathematics	60 minutes daily	60 minutes daily
Science	30 minutes daily	45 minutes daily
Social Studies	30 minutes daily	45 minutes daily
Physical Education	30 minutes daily*	30 minutes daily*
Health	60 minutes weekly	60 minutes weekly
Technology Education (Computer Applications)	60 minutes weekly	60 minutes weekly
Character Education	10 minutes daily**	10 minutes daily**
Arts Education		

Dance Music Theatre Visual Arts	*Daily instruction with certified arts specialists in each of the arts disciplines is the most desirable schedule. However, schools unable to provide daily arts instruction in each discipline are encouraged to schedule in Grades 1 through 3 two 30- to 45-minute arts instruction sessions per week and in Grades 4 through 6 a minimum of 60 minutes of instruction per week. Interdisciplinary instruction within the regular classroom setting is encouraged as an alternative approach for scheduling time for arts instruction when certified arts specialists are not available.*

* Established by the Alabama State Department of Education in accordance with *Code of Alabama*, 1975, §16-40-1

** Established by the Alabama State Department of Education in accordance with *Code of Alabama*, 1975, §16-6B-2(h)

Kindergarten

In accordance with *Alabama Administrative Code* r. 290-5-1-.01(5) Minimum Standards for Organizing Kindergarten Programs in Alabama Schools, the daily time schedule of the kindergartens shall be the same as the schedule of the elementary schools in the systems of which they are a part since kindergartens in Alabama operate as full-day programs. There are no established time guidelines for individual subject areas for the kindergarten classroom. The emphasis is on large blocks of time that allow children the opportunity to explore all areas of the curriculum in an unhurried manner.

It is suggested that the full-day kindergarten program be organized utilizing large blocks of time for large groups, small groups, center time, lunch, outdoor activities, snacks, transitions, routines, and afternoon review. Individual exploration, small-group interest activities, interaction with peers and teachers, manipulation of concrete materials, and involvement in many other real-world experiences are needed to provide a balance in the kindergarten classroom.

Grades 7-12

One credit may be granted in Grades 9-12 for required or elective courses consisting of a minimum of 140 instructional hours or in which students demonstrate mastery of Alabama course of study content standards in one-credit courses without specified instructional time (*Alabama Administrative Code* r. 290-3-1-.02 (9)(a)).

In those schools where Grades 7 and 8 are housed with other elementary grades, the school may choose the time requirements listed for Grades 4-6 or those listed for Grades 7-12.

Character Education

For all grades, not less than 10 minutes instruction per day shall focus upon the students' development of the following character traits: courage, patriotism, citizenship, honesty, fairness, respect for others, kindness, cooperation, self-respect, self-control, courtesy, compassion, tolerance, diligence, generosity, punctuality, cleanliness, cheerfulness, school pride, respect of the environment, patience, creativity, sportsmanship, loyalty, and perseverance.

Homework

Homework is an important component of every student's instructional program. Students, teachers, and parents should have a clear understanding of the objectives to be accomplished through homework and the role it plays in meeting curriculum requirements. Homework reflects practices that have been taught in the classroom and provides reinforcement and remediation for students. It should be student-managed, and the amount should be age-appropriate, encouraging learning through problem solving and practice.

At every grade level, homework should be meaning-centered and mirror classroom activities and experiences. Independent and collaborative projects that foster creativity, problem-solving abilities, and student responsibility are appropriate. Parental support and supervision reinforce the quality of practice or product as well as skill development.

Each local board of education shall establish a policy on homework consistent with the Alabama State Board of Education resolution adopted February 23, 1984 (Action Item #F-2).

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