Hill & Lowe Educational Services, Inc.
The Hill & Lowe Foundation
Exploratorium Academy

Curriculum Design

Science Education

The following are State Approved Courses and Course Descriptions for (Alabama) High School Students. These and other correlated content standards may be found on our official web-page.

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9 – 12 Overview (Science Education)

The high school curriculum is the last experience with formal educational instruction for some students. To enable all students to become scientifically literate, the science curriculum in Grades 9-12 must provide students with the knowledge and skills necessary for the twenty-first century. Therefore, the *Alabama Course of Study: Science* becomes more focused in the content of the traditional disciplines of Biology, Chemistry, and Physics. In addition, it now defines ten electives cores in the more specialized areas of Anatomy and Physiology, Aquascience, Astronomy, Botany, Earth and Space Science, Environmental Science, Genetics, Geology, Marine Biology, and Zoology. Within these disciplines, however, minimum required content is organized in categories similar to those used in Grades K-8, thus showing unity in the entire K-12 program. All science courses in Grades 9-12 are laboratory-based courses.

The Alabama Administrative Code requires that Alabama courses of study are followed when local school systems establish graduation requirements. The *Alabama Course of Study: Science* specifies required science content in a manner intended to balance a need for increased rigor in course offerings and consistency statewide with the need for local flexibility in designing those offerings. According to the *Alabama Administrative Code* r.290-3-1-.02(8)(e)2, a student cannot earn credit toward graduation for a course that duplicates course content for which credit has previously been given. Options to satisfy current graduation requirements for students seeking the Alabama High School Diploma and the Alabama High School Diploma with Advanced Academic Endorsement are shown below.

The *Alabama Course of Study: Science* provides Content Standards within 14 areas. These cores represent fundamental concepts and skills that all Alabama students should know and be able to do to become scientifically literate. Local school systems may develop courses expanding the Core Content to address specific needs of the local student population or to utilize local resources, thereby retaining the identified core as the foundation. The presentation of the minimum required content in the *Alabama Course of Study: Science* is not intended to restrict local school systems from designing course offerings and multiple-year sequences of course offerings of a more integrated nature. However, integrated programs must incorporate the content of the Physical Science (or Chemistry and Physics), Biology, and Earth and Space Cores and be approved at the state level.

At Grades 9-12 in each Core, Content Standards are organized into two main categories: Scientific Process and Application Standards and Scientific Knowledge Standards. The Scientific Knowledge Standards refer to what students must know or be able to do. Scientific process refers to the "methods" and "habits" required to investigate as scientists investigate. These are to be infused into instruction of all Scientific Knowledge Standards; it is not the intent to teach them in isolation. Since they comprise part of the content, Process and Application Standards will be applied to the learning experience for all science disciplines. The major emphasis of the Process and Application Standards is based on the philosophy of "how science is done" and "why science is done."

In designing instructional units and strategies, teachers are encouraged to integrate processes, application, and knowledge within lessons. As advocated by the *National Science Education Standards* produced by the National Research Council (NRC), the emphasis is on acquiring understanding and developing a foundation for using scientific knowledge and processes. In all Grades 9-12 courses, students are involved in firsthand observation, investigation, experimentation, and communication of results and conclusions. As facilitator of inquiry-based instruction, the teacher guides student investigations by emphasizing active participation in data collection and analysis, problem solving, and defense of explanations. (See the 5 E Instructional Model on page 7.) Although curriculum is organized by separate domains and disciplines, instruction should emphasize connections among science disciplines and between science and other fields of study. The increasing demand for technological proficiency makes the use of technology in all science classrooms and laboratories essential. Students are encouraged to conduct research in a particular science subject and relate it to the community in the form of service projects. Student achievement in these areas should be measured with a variety of assessment tools.

The cognitive level of the student in Grades 9-12 must be considered when planning instruction. Students are making the transition from concrete thinking to formal operational reasoning. Therefore, field and laboratory experiences help to bridge the transition. Misconceptions concerning many scientific phenomena are abundant at this age level. Teachers should work diligently to uncover these misconceptions and help students to recognize them as misconceptions. This can be done through the use of discrepant events and demonstrations that cause students to ask "why" their experiences or logic does not always agree with scientific explanations.

PHYSICAL SCIENCE CORE

Physical Science, as presented in this document, is an inquiry-based Core including basic concepts and skills in chemistry and physics that are considered foundational in those disciplines. Emphasis is placed on three Scientific Knowledge strands: Properties and Changes in Matter, Forces and Motions, and Interactions of Energy and Matter. Scientific Process and Application Standards should be addressed in conjunction with Scientific Knowledge Standards in this laboratory-based course.

The Physical Science Core emphasizes first-hand observation through laboratory investigations, practical problem solving, and the use of technology. Special attention is given to scientific application of knowledge and processes to practical real-world questions. This Core, developed around the fundamental concepts of chemistry and physics, will vary from the chemistry and physics courses in the amount and types of experimentation, technical application, and instrumentation. It provides students lacking a strong Physical Science knowledge base with a firm laboratory-based foundation for scientific literacy and for the pursuit of subsequent science courses.

In this age of technology, students experiment with instrumentation. The required technology for the Physical Science Core consists of basic instruments that, in some cases, students can construct. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and chemicals.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science-thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables simultaneously.

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Identify the effects of technology on daily life.
    Examples: cellular phones, fiber optics, microwaves, lasers

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

PROPERTIES AND CHANGES IN MATTER

17. Trace the changing model of the atom from that of Democritus to the present quantum model.

18. Demonstrate use of the Bohr model.
    - Describing the electron configuration of elements in the periodic table
    - Relating electron configuration to valence and oxidation number
    - Comparing the roles of electrons in covalent, ionic, and metallic bonding

19. Differentiate between physical and chemical properties/changes.

20. Demonstrate use of the periodic table for key purposes.
    - Determining number of protons, electrons, and neutrons
    - Classifying elements
    - Determining reactivity
    - Writing formulas
    - Identifying types of compounds formed

21. Classify matter according to characteristic properties.
    Examples: metals, nonmetals and metalloids, covalent and ionic compounds; solutions and suspensions

22. Explain the formation of unsaturated, saturated, and supersaturated solutions.

23. Describe the effects of factors that influence solubility and rate of solution.
    - Nature of solute and solvent
    - Temperature
    - Agitation
    - Surface area
    - Pressure of gases

24. Write simple formula and chemical word equations for the four basic types of reactions.
    - Synthesis
    - Decomposition
    - Single replacement
    - Double replacement

25. Illustrate the Law of Conservation of Mass by balancing simple chemical equations.

26. Describe factors that affect rates of reaction.
    - Temperature
    - Concentration
    - Surface area
    - Catalysts
    - Nature of reactants

27. Analyze the properties and interactions of acids and bases.

FORCES AND MOTIONS

28. Identify the basic natural forces.
    - Gravitational
    - Electromagnetic
    - Strong nuclear
    - Weak nuclear

29. Apply quantitative relationships and associated graphical representations among position, displacement, distance, time, speed, velocity, and acceleration.

30. Add parallel vector quantities (in the same or opposite directions) to determine a resultant.
    Example: effect of tailwind/headwind on an airplane

31. Describe relationships between force and motion in Newton's laws.
    - Inertia
    - Acceleration
    - Action/reaction

32. Apply the quantitative relationships among force, distance, work, time, and power.

33. Analyze the nature of simple machines.
    - Mechanical advantage
    - Efficiency

34. Explain tradeoffs in the use of simple machines to do work.
    Examples: ramp–increased distance traded for decreased effort force;
    bicycle–increased speed exchanged for greater effort force

35. Apply quantitative relationships among force, area, and pressure in fluids.
    Examples: buoyancy, hydraulics (Pascal's law), Bernoulli effects

36. Explain the relationships among mass, velocity, force, and momentum.

INTERACTIONS OF ENERGY AND MATTER

37. Describe mathematically the relationships among potential energy, kinetic energy, and work.

38. Explain phase changes in terms of the effect of energy on particle motion.
    Examples: ice changing from water and then to steam, slow particle movement changing to medium and then to fast

39. Illustrate the law of conservation of energy.
    - Potential energy to kinetic energy
      Example: falling object
    - Transformation of energy forms
      Example: hairdryer transforming electrical energy to heat energy

40. Explain methods of heat transfer.
    - Conduction
    - Radiation
    - Convection

41. Describe the transfer of energy through waves.
    - Mechanical energy (energy content as it relates to amplitude)
    - Electromagnetic energy (energy content as it relates to frequency)
    - Transverse waves
    - Longitudinal waves

42. Identify wave characteristics.
    - Wavelength
    - Frequency
    - Period
    - Amplitude
    - Speed

43. Relate physical properties of sound and light to wave characteristics.
    Examples: loudness to amplitude, pitch to frequency, color to wavelength and frequency

44. Analyze interactions of light and matter.
    - Prisms
    - Concave/convex mirrors
    - Concave/convex lenses

45. Describe characteristics and behavior of static charge.
    - Creating charge
    - Transferring charge through induction and conduction

46. Explain the relationship between electricity and magnetism.
    Examples: a moving charge creates a magnetic field, a moving magnetic field may induce a current in a closed wire loop

47. Apply Ohm's law to electrical circuits.

48. Understand basic nuclear concepts.
    - Identifying three types of nuclear emissions (alpha particle, beta particle, gamma radiation)
    - Differentiating between fission and fusion

BIOLOGY CORE

Most advances in scientific knowledge and technology have been slow and incremental. The early labors of Robert Hooke and Anton van Leeuwenhoek led to work on the cell theory during the seventeenth and eighteenth centuries. Mendel's meticulous study of pea plants and Darwin's informed observations during the voyage of *HMS Beagle* laid the foundation for modern genetics and the theory of evolution by natural selection during the nineteenth century. The twentieth century saw ground-breaking work by giants such as George Washington Carver in plant science and Barbara McClintock in molecular genetics. Edward O. Wilson, Alabama's native son, has raised the standard of interdisciplinary science investigations.

With the elucidation of the structure of DNA in 1953 using Rosalind Franklin's X-ray diffraction pictures, the study of cellular biology changed forever. The shift toward molecular biology and the many breakthroughs made possible by new approaches and technology set the stage for the current exciting work on the frontier of science known as the Human Genome Project. With the advent of anticipated breakthroughs and the personal, environmental, and societal issues they will raise, scientific literacy for all Alabama citizens is essential.

The Biology Content Standards constitute the Biology Core and should be included in all first-year biology courses. This Core includes scientific knowledge emphasizing in-depth study of the strands of Structure and Function of Living Systems, Diversity and Adaptations, Heredity and Reproduction, and Organisms and Environment. Although emphasis is on Life Science content, many possible connections to topics in the Physical Science and Earth and Space Science domains can be made. The Biology Core continues to define scientific processes and scientific applications as significant parts of the content.

This Biology Core is not intended to serve as an entire curriculum of any course. Teachers are encouraged to take their students beyond the limits of this Core content. It is also important to note that depth of understanding, not breadth of content, is the goal of the biology curriculum. To reduce the amount of content, material already studied is not repeated; and some traditional topics have been omitted or given less emphasis than in the past. The Core requires more emphasis on open-ended laboratory exploration of questions posed and less on memorization of discrete facts as well as more on active investigation and analysis of ideas and less on recitation or passive listening. While important to the study of biology, vocabulary should be a means to understanding and communicating rather than an end unto itself.

The emphasis on molecular biology in the twenty-first century requires that students are familiar with basic ideas and skills in chemistry presented in the middle school curriculum and/or in the Physical Science Core. Technology and special techniques are needed to explore amino acids, proteins, and DNA in the laboratory. It is essential for students to put the theories and discoveries of significant persons into an historical perspective. Students should recognize the importance of using clear and accurate language in discussions, record keeping, reports, project presentations (both oral and written), and debates regarding the results and conclusions of scientific investigations. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction skills.

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Operation of the universe that is discoverable and understandable
    - Linkage of natural causes with natural effects
    - Operation of the universe that is consistent and predictable

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
    Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
    - Observing
    - Classifying
    - Measuring with appropriate units and significant figures
    - Inferring
    - Predicting
    - Solving problems
    - Interpreting data
    - Designing experiments
    - Formulating hypotheses
    - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknowns by manipulating variables.
   Examples: blood typing, methods of pollination, color of light in photosynthesis

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Identify the uses of technology in scientific applications.
    Examples: lasers and optics in industrial and medical technology, protein crystal growth in microgravity on drug production

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

The Cell

17. Identify the basis of the cell theory.

18. Analyze relationships among cell structure, function, and organization in prokaryotes and eukaryotes.
    Examples: prokaryote (archaebacteria, eubacteria), eukaryote (plants, animals, protists, fungi)

19. Analyze the process by which cells become specialized even though DNA is identical in every cell within an organism.

20. Relate cellular functions to specialized structures within cells.
    - Active and passive transport of materials (osmosis, diffusion)
    - Energy capture and release
    - Protein synthesis

- Waste disposal
- Information feedback
- Movement

21. Analyze factors that can affect cellular activities.
    - Molecular factors
      Examples: carbohydrates, lipids, proteins, nucleic acids
    - Environmental factors
      Examples: acidity, temperature extremes, light
    - Structural factors
      Examples: surface area, cell size

22. Differentiate among cells undergoing the stages of mitosis and meiosis.

Matter, Energy, and Organization in Living Systems

23. Identify the levels of organization of living things.
    - Cells
    - Tissues
    - Organs
    - Systems
    - Organisms
    - Population
    - Community

24. Analyze the flow of matter and energy through different trophic levels and between organisms and the physical environment.
    - Food chain
    - Food web
    - Food pyramid

25. Describe selected biogeochemical cycles.
    - Water
    - Carbon
    - Nitrogen
    - Phosphorus

DIVERSITY AND ADAPTATIONS

Biological Evolution

26. Analyze the theory of evolution by natural selection.
    - Identifying theoretical bases
      Examples: comparative anatomy, DNA sequence, embryology
    - Identifying types of adaptations to environmental conditions
      Examples: behavioral, physiological, structural
    - Identifying theoretical mechanisms
      Examples: genetic drift, isolation, acquired characteristics

27. Identify species by comparing molecular and anatomical evidence.
28. Use taxonomic groupings to differentiate structures, life cycles, and major characteristics of each kingdom.

- Nonvascular plants
- Vascular plants
- Gymnosperms
- Angiosperms
- Invertebrates
- Vertebrates
- Protista
  Examples: ciliates, flagellates, sarcodinas
- Fungi
  Examples: bread molds, penicillin, mildew
- Monera (Bacteria)
  Examples: archaebacteria, eubacteria

29. Discuss the relationships among organisms as the basis for biological systems of classification.

30. Understand why natural selection and genetic drift affect populations rather than individuals.

31. Describe the use of isotopic dating in determining the geologic age of fossils.

HEREDITY AND REPRODUCTION

Molecular Basis of Heredity

32. Recognize heritable characteristics of organisms.
    - Physical structure
    - Chemical composition
    - Behavior

33. Explain the transfer of information from parents to offspring through genes within DNA molecules.
    - Mitosis
    - Meiosis
    - Protein synthesis

34. Apply Mendel's laws to determine possible combinations of offspring.
    - Monohybrid cross
    - Dihybrid cross

35. Identify the genetics in commonly inherited disorders.
    - Sex-linked disorders
      Example: colorblindness
    - Sex-influenced disorders
      Example: patterned baldness

36. Analyze factors in the population that cause genetic mutations in an organism and/or its offspring.
    - Radiation
    - Chemicals
    - Chance

37. Predict positive and negative outcomes of biotechnology.
    - Genetic alteration
    - Selective breeding
    - Cloning
    - Treatments for disease

ORGANISMS AND ENVIRONMENTS

Interdependence of Organisms

38. Relate the biotic and abiotic factors of the environment.

39. Discuss factors that affect the dynamic equilibrium of ecosystems.
    - Disasters
      Examples: fire, flood
    - Climate changes
    - Introduction of new species
    - Activities of organisms
      Example: human impact–destruction, management, and conservation of natural resources
    - Succession
      Examples: primary, secondary

40. Describe biomes.
    Examples: salt and fresh water, deciduous forests, tropical rainforests, tundra

41. Explain different relationships among living organisms.
    - Competition
    - Symbiosis (mutualism, commensalism, parasitism)
    - Producer/consumer/decomposer (autotrophs, heterotrophs)
    - Predator/prey (mimicry, camouflage)

42. Describe structure and characteristics of viruses as they relate to living systems.
    Examples: HIV replication, bacteriophages

CHEMISTRY CORE

Citizens of today encounter consumer, health, safety, environmental, technological, societal, and scientific issues on a daily basis. To deal with these issues intelligently, the scientifically literate person must have a fundamental understanding of the most basic chemistry concepts associated with the structure, forms, changes, availability, and uses of matter and energy. The Chemistry Core content defines the fundamental knowledge and skills necessary for such literacy.

The Chemistry Core Content Standards are appropriate for senior high students. They comprise the Chemistry Core that is to be incorporated into all first-year chemistry courses, regardless of instructional content. The Core itself is not intended to serve as the entire curriculum of any course. Scientific knowledge in the Chemistry Core focuses on the Interactions of Matter and Energy as well as Properties and Changes in Matter. Although emphasis is on these Physical Science strands, many possible connections to Earth and Space Science as well as Life Science topics should be made. Teachers are encouraged to expand their chemistry curriculum beyond the limits of this Core content. Different chemistry courses developed from the Chemistry Core will vary in the amount and kind of experimentation, technical applications, and instrumentation. They will also vary in the level of difficulty and abstractness. All chemistry courses developed from this Content Core should be laboratory-based. They should encourage critical thinking and the use of basic chemical concepts and scientific strategies for students to make intelligent decisions and to solve practical problems.

Technology is an important component of the Chemistry Core and is used to measure (quantify), to probe, and to analyze matter and energy. This technology includes probeware and devices such as spectroscopes that can be interfaced with computer- or calculator-based programs so that data are acquired directly during investigations both inside and outside the school laboratory. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. The recommended prerequisite math course is Algebra I. Physical Science is recommended for students who have not mastered the rigorous integrated middle school curriculum in this document

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
    Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and chemicals.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science-thinking skills.
    - Observing
    - Classifying
    - Measuring with appropriate units and significant figures
    - Inferring
    - Predicting
    - Solving problems
    - Interpreting data
    - Designing experiments
    - Formulating hypotheses
    - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
    Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables.
    Examples: stoichiometry, gas laws, ionization constants

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Identify the uses of technology in scientific applications.
    Examples: metal spectroscopy, gas chromatography, crystallography in microgravity

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

PROPERTIES AND CHANGES IN MATTER

Properties and Changes in Matter

17. Differentiate the classifications of matter.
    - Pure substances
      Examples: elements, compounds
    - Mixtures
      Examples: homogeneous, heterogeneous

18. Differentiate between physical and chemical properties/changes.

19. Use the kinetic theory to explain the states and properties (microscopic and macroscopic) of matter.
    Example: change in interparticle distance and attractive forces

Structure of Atoms

20. Use the periodic table to determine the number of protons, electrons, and neutrons in isotopes of elements.

21. Summarize benchmark discoveries in the historical development of the atomic theory.
    Examples: Thomson's cathode ray, results of Rutherford's gold foil and Millikan's oil drop experiments, photoelectric effect, absorption and emission spectra of elements

22. Describe atoms using different electron notations.
    - Electron configuration
    - Orbital notation
    - Electron dot notation
      Example: Lewis symbol

Periodic Table

23. Use the periodic table for specific purposes.
    - Predicting patterns of change of properties by groups and periods
    - Classifying elements as metals, nonmetals, metalloids, noble gases
    - Predicting bond types
    - Assigning valences/oxidation numbers based on electron configuration

Solutions

24. Describe the preparation and properties of solutions.
    - Components
    - Classifications
    - Solubility and concentrations
    - Conductivity
    - Colligative properties

25. Relate certain factors to solubility and rate of solution.
    - Nature of solute and solvent
    - Temperature
    - Agitation
    - Surface area
    - Pressure of gases

26. Understand the nature and interactions of acids and bases.
    - Proton donors or acceptors
    - Physical properties
      Examples: taste, conductivity
    - Effects on indicators
    - Neutralization reactions
    - Degree of ionization
      Examples: weak or strong, diluted or concentrated, pH

Nuclear

27. Compare characteristics of isotopes of the same element.
    - Nuclear composition
    - Stability
    - Physical properties
    - Chemical properties

28. Demonstrate an understanding of basic nuclear concepts and issues.
    - Distinguishing between nuclear and chemical changes
    - Identifying three types of nuclear radiation (alpha, beta, gamma)
    - Applying half life to dating techniques
    - Differentiating fission and fusion
    - Evaluating environmental issues associated with nuclear waste

INTERACTIONS OF MATTER AND ENERGY

Interactions of Matter and Energy

29. Compare and contrast bond types.
    - Ionic

- Covalent
  Examples: inorganic–water, organic–glucose
- Metallic

30. Apply rules of nomenclature and formula writing.
    Examples: carbon dioxide–CO_2, calcium carbonate–$CaCO_3$

31. Demonstrate an understanding of matter interactions.
    - Writing balanced chemical equations
    - Identifying chemical reactions
    - Analyzing stoichiometric relationships
      Examples: particles, masses, moles, volumes

32. Apply quantitative relationships among pressure, volume, temperature, and number of particles in ideal gases.

33. Analyze factors affecting reaction rates in relation to the kinetic theory.
    - Temperature
    - Surface area
    - Catalyst
    - Concentration
    - Nature of reactants

34. Explain physical and chemical changes as endothermic and exothermic energy changes.
    - Specific heat calculations
    - Heats of fusion and vaporization
    - Heats of solution
    - Heats of reaction

35. Apply LeChatelier's principle to explain a variety of changes in physical and chemical equilibria.

PHYSICS CORE

Physics is the branch of science that addresses the properties of physical matter, physical quantities, and their relationships. Physics consists of studies of motion, force, energy, heat, light, sound, fluids, electricity, and magnetism.

The Physics Content Standards comprise the Physics Core to be incorporated into all first-year physics courses. The Core itself is not intended to serve as the entire curriculum of any course but as a basis upon which to build a course. Teachers are encouraged to expand the physics curriculum beyond the limits of this Core Content. The differences among physics courses developed using this Core will be in the extent and sophistication of experimentation, content, technical applications, and instrumentation as well as in the level of difficulty and abstractness. All physics courses developed from the Content Core should be laboratory-based.

The Physics Core provides the opportunity for students to expand their knowledge of physical phenomena through an in-depth study of the two Physical Science strands: (1) Forces and Motions and (2) Interactions of Energy and Matter.

Some basic concepts and skills are not addressed in the Core because these have been introduced in earlier grades. As a result of taking courses developed from the Content Core, students can develop the ability to think critically, to make intelligent decisions, and to solve practical problems related to matter and energy. These Content Standards de-emphasize the working of narrow algorithmic problems in favor of understanding and being able to describe and interpret quantitative relationships in physics.

Computer-centered technology is an important component of any physics course developed from this Content Core. The use of probeware such as photogates, pressure sensors, and nuclear scalers should be included. Probeware can be interfaced with calculator-based or computer-based programs so that data can be acquired directly during investigations and then manipulated and analyzed later. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. The recommended prerequisite math course is Algebra II. Physical Science is recommended for students who have not mastered the rigorous integrated middle school curriculum in this document.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
    Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments and equipment.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science-thinking skills.
    - Observing
    - Classifying
    - Measuring with appropriate units and significant figures
    - Inferring
    - Predicting
    - Solving problems
    - Interpreting data
    - Designing experiments
    - Formulating hypotheses
    - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
    Example: calculate mean, median, mode, standard deviation, percent error, and linear regressions from sample data

9. Solve for unknown quantities by manipulating variables.
    Example: calculating tension

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Identify the uses of technology in scientific applications.
    Examples: lasers and optics in industry and medical imaging, communication devices, microelectronics

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computers or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

FORCES AND MOTIONS

17. Describe the basic natural forces.
    - Gravitational
    - Electromagnetic
    - Strong nuclear
    - Weak nuclear

18. Understand the interrelationships among mass, distance, force, velocity, acceleration, and time.
    - Linear motion
    - Uniform circular motion
    - Projectile motion

19. Explain the significance of slope and area under a curve when graphing motion data.
    Example: relationship between the distance-time graph and the velocity-time graph

20. Analyze vector problems graphically and trigonometrically.
    Example: develop a free body diagram

21. Use vectors to analyze the motion of an object acted upon by more than one force.
    Example: resultant effect of friction, gravity, and the normal force on an object sliding down an inclined plane

22. Demonstrate an understanding of momentum.
    - Calculating the momentum for a single object and the momenta for a group of objects
    - Verifying the law of conservation of momentum from observations of one-dimensional collisions

23. Explain planetary motion and navigation in space in terms of Kepler's and Newton's laws.

24. Apply quantitative relationships involving mass, weight, distance, work, power, gravitational potential energy, and kinetic energy.

25. Explain the laws of thermodynamics.

26. Describe relationships qualitatively and quantitatively between changes in heat energy and changes in temperature.

INTERACTIONS OF ENERGY AND MATTER

Waves

27. Classify waves according to type.
    - Mechanical or electromagnetic
    - Transverse or longitudinal

28. Explain wave behavior in terms of reflection, refraction, and diffraction.

29. Differentiate between constructive and destructive wave interference.

30. Relate physical properties of sound and light to wave characteristics.
    Examples: loudness to amplitude, pitch to frequency, color to wavelength and frequency, red shift to Doppler effect

31. Explain the impact of change in media upon the speed, frequency, and wavelength of a wave.

32. Describe how different components of the electromagnetic spectrum are used for communication purposes.
    Examples: laser radiation, microwave radiation, radio waves

Light

33. Demonstrate an understanding of reflection.
    Examples: tracing the path of a reflected light ray, predicting the formation of reflected images through tracing of rays and use of the mirror equation

34. Demonstrate an understanding of refraction.
    Examples: tracing and calculating the path of a refracted light ray through prisms using Snell's law, predicting the formation of refracted images through ray tracing and use of the lens equation

35. Demonstrate an understanding of diffraction.
    Examples: Huygen's principle and how it applies to diffraction; calculation of position of bright spots formed by monochromatic light passing through a pair of slits; measurement of wavelength of monochromatic light knowing slit separation, distance to screen, and position of bright spots

36. Explain polarization.
    - Production
    - Characteristics
    - Uses

Electricity/Magnetism

37. Describe similarities in the calculation of electrical force, magnetic force, and gravitational force between objects.

38. Explain the production of static change in an electroscope through induction and conduction.

39. Identify methods by which an electric field can be created.
    Examples: rubbing materials together (friction), using batteries (chemical means), moving a closed loop of wire across a magnetic field

40. Apply quantitative relationships among charge, current, potential energy, potential difference, resistance, and electrical power for simple series, parallel, or combination DC circuits.

41. Determine the force on charged particles using Coulomb's law.

Modern Physics

42. Demonstrate an understanding of the scientific implications of the following as they relate to the nature of particles (atoms).
    - Thomson's cathode ray experiment (e^{-}/m ratio)
    - Rutherford's gold foil experiment (discovery of the nucleus)
    - Bohr's bright line spectra experiment (quantized atomic shell model)
    - Millikan's oil drop experiment (fundamental electron charge)
    - DeBroglie's wave theory (wave nature of matter)
    - Einstein's photoelectric-effect theory (particle/wave duality)
    - Michelson/Morley theory (electromagnetic rays requiring no medium)

ANATOMY AND PHYSIOLOGY ELECTIVE CORE

The Anatomy and Physiology Elective Core contains content regarding the structure and function of the components of the human body. It is designed especially for students who are interested in pursuing careers in the medical and allied health fields. Among the topics students will study are the structure and function of cells, tissues, and organs; organization of the human body; biochemistry; and the skeletal, muscular, nervous, endocrine, digestive, respiratory, circulatory, lymphatic, immune, excretory, and reproductive systems. The laboratory setting encourages students to apply the knowledge and processes of science while independently seeking answers to questions of personal interest and importance. Dissection, histological studies, and physiology are featured laboratory experiences.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Anatomy and Physiology curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should be laboratory-based. They should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. The recommended prerequisite science course is Biology. The minimum required content comprises the Core of an elective introductory Anatomy and Physiology course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknowns by manipulating variables.
   Examples: blood typing, pH

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Identify specific technology important in the areas of applied anatomy and physiology.

15. Apply knowledge of wave characteristics to medical technology.
    Examples: lasers, optics

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

The Cell

17. Relate cellular functions to specialized structures within cells.
    - Active and passive transport of materials (osmosis, diffusion)
    - Energy capture and release
    - Protein synthesis
    - Waste disposal
    - Information feedback
    - Movement

18. Analyze factors that can affect cellular activities.
    - Molecular factors
      Examples: carbohydrates, lipids, proteins, nucleic acids
    - Environmental factors
      Examples: acidity, temperature extremes, light
    - Structural factors
      Examples: surface area, cell size

19. Differentiate between cells undergoing the stages of mitosis and meiosis.

20. Identify the levels of organization of living things.
    - Cells
    - Tissues
    - Organs
    - Systems
    - Organisms

Matter, Energy, and Organization in Living Systems

21. Explain the importance of and processes for maintaining constancy of pH in the human body.

22. Comprehend the control mechanisms in the human body used for regulation and integration of the nervous system, the senses, and the endocrine system to maintain homeostasis.

23. Identify energy needs and energy-producing processes in the human body.
    - Digestive processes
    - Absorption processes
    - Respiratory processes (cellular and anatomical)

24. Describe electrical conduction systems, processes, and regulating mechanisms within the human body.

25. Explain basic assumptions and conclusions of the atomic theory.

26. Compare and contrast bond types.
    - Ionic
    - Covalent

Examples: inorganic–water, organic–glucose

- Metallic

27. Write simple formula and chemical word equations for the four basic types of reactions.
    - Synthesis
    - Decomposition
    - Single replacement
    - Double replacement

28. Classify the major types of tissues.
    - Epithelium
    - Connective
    - Muscle
    - Nerve

29. Analyze the relationships between anatomical structures and physiological functions of systems in the human body.
    - Integumentary
    - Skeletal
    - Muscular
    - Nervous
    - Cardiovascular
    - Digestive
    - Respiratory
    - Reproductive

30. Determine how the human body integrates functions within and among various maintenance systems.
    - Endocrine
    - Cardiovascular
    - Digestive
    - Respiratory
    - Excretory
    - Lymphatic
    - Immune

HEREDITY AND REPRODUCTION

Molecular Basis of Heredity

31. Relate embryology, heredity, and reproduction in humans.

32. Distinguish characteristics in terms of genotype and phenotype.
    Examples: genetic diseases, expression of a recessive trait, sex-linked traits

33. Identify research resulting from knowledge gained in the human genome project.

Dr. Mary Hill Lowe – Director
Approved Courses of Study – Science Education
State of Alabama

ENVIRONMENTAL SCIENCE ELECTIVE CORE

Environmental Science introduces students to a broad view of the biosphere and the physical parameters that affect it. While Ecology emphasizes life science aspects of the environment almost exclusively, Environmental Science courses emphasize Physical and Earth Science components involved in biogeochemical cycles that impact biomes. Students study a variety of topics including biotic and abiotic factors in habitats, ecosystems, and biomes; interrelationships between resources and environmental systems; sources and flow of energy through environmental systems; factors that influence carrying capacity; and natural and man-made environmental changes.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Environmental Science curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. Recommended prerequisite science courses are Biology and Physical Science or Biology and Chemistry. The minimum required content comprises the Core of an elective introductory Environmental Science course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing questions carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.
   Examples: allergies, poisons in plants and animals

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables.
   Examples: water quality analysis, nutrient load, population change

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the environmental advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Identify uses of technology in daily environmental applications.
    Examples: air quality, pollution index, satellite sensing

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

Matter, Energy, and Organization in Living Systems

17. Recognize the components of the dynamic Earth.
    - Characteristics of the planet Earth
    - Components of the biosphere
      Examples: abiotic factors, biotic factors

18. Distinguish among the various biomes.
    - Desert and tundra
    - Grassland
    - Forest
      Examples: tropical rain forest, temperate rain forest, temperate deciduous forest, taiga
    - Freshwater
    - Marine

19. Describe the interaction of matter and energy in the biosphere.
    - Producers, consumers, decomposers (autotrophs and heterotrophs)
    - Food chain/food web
    - Energy pyramids

20. Describe the biogeochemical cycles in the biosphere.
    - Carbon cycle
    - Nitrogen cycle
    - Oxygen cycle
    - Phosphorus cycle
    - Water cycle

21. Identify characteristics of water chemistry in different aqueous environments.
    - Fresh water
      Examples: lakes, streams, ponds
    - Brackish water
      Examples: bays, inland seas, marshes
    - Salt water
      Example: open oceans

DIVERSITY AND ADAPTATIONS

Biological Evolution

22. Analyze succession in various ecosystems.
    - Isolated ecosystems
      Examples: Australia, Galapagos Islands
    - Sea floor vents
      Examples: worms, chemosynthetic bacteria
    - Devastated environments

ORGANISMS AND ENVIRONMENTS

Interdependence of Organisms

23. Relate carrying capacity and changes in populations and ecosystems.
    - Geographical locales/migration
    - Natural events
    - Diseases
    - Birth and death rates

24. Investigate the human impact on the environment.
    - Depletion of natural resources
    - Point and nonpoint pollution
    - Air and water quality
    - Ozone depletion
    - Habitat destruction
    - Introduction/removal of non-native organisms

25. Illustrate how regional environmental changes have had global effects.

26. Analyze the management of natural resources.
    - Renewable and nonrenewable resources
    - Economic significance of natural resources

27. Identify methods of stewardship of natural resources to ensure a sustainable quality of life for future generations.

DYNAMIC EARTH

28. Explain how the biogeochemical cycles recycle resources through the atmosphere, hydrosphere, lithosphere, and biosphere.

29. Identify how different biomes affect the various components of the atmosphere.

30. Identify the relationships between landforms and types of biomes.
    - Beaches
    - Piedmonts
    - Deserts
    - Plateaus
    - Plains
    - Mountains

GENETICS ELECTIVE CORE

The Genetics Core focuses on two Life Science sub-strands: Biological Evolution and Molecular Basis of Heredity. With rapid advances in sequencing the Human Genome, there has been an explosion of information and applications in Genetics and related fields. Students should be involved in genetics investigations such as those available through the Alabama Science in Motion (ASIM) program. Case studies in biotechnology and scenarios in bioethics can help students understand the implications and complicated issues that are emerging as the science of Genetics continues to develop.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Genetics curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. Recommended prerequisite science courses are Biology and Physical Science or Biology and Chemistry. The minimum required content comprises the Core of an elective introductory Genetics course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables.
   Examples: Hardy-Weinberg equation, probability problems

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on genetic engineering.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning in the fields of genetics and genetic engineering.
    Examples: Internet usage, online/distance learning

15. Identify the uses of technology in daily genetics-related applications.
    Examples: gel electrophoresis, forensic studies, neo-natal care

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

DIVERSITY AND ADAPTATIONS

Biological Evolution

17. Analyze the Hardy-Weinberg principle as a model to demonstrate the occurrence of evolution in response to five forces.
    - Natural selection
    - Genetic drift
    - Mutation
    - Non-random mating
    - Migration

18. Analyze factors in populations that cause mutations.
    - Radiation
    - Chemicals
    - Chance

HEREDITY AND REPRODUCTION

Molecular Basis of Heredity

19. Understand the significance of Mendel's work to the development of the modern science of genetics.

20. Relate genetic problems to Mendel's laws of segregation and independent assortment.

21. Describe the process of meiosis and its hereditary significance.
    - Stages
    - Genetic variability

22. Describe inheritance patterns based on chromosomes, genes, alleles, and gene interaction.
    - Dominant and recessive traits
    - Incomplete dominance and co-dominance

23. Describe the occurrences and effects of sex linkage, autosomal linkage, crossover, multiple alleles, polygenes, and pleiotropy.

24. Explain the transfer of information from parent to offspring through genes within DNA molecules.
    - Genetic code
    - Gene expression (protein synthesis)
    - Gene regulation

25. Evaluate the Watson-Crick model of the DNA structure.

26. Describe the structure and function of DNA.
    - Replication
    - Translation
    - Transcription

27. Explain the structure of an eukaryotic chromosome.
    - Transposons
    - Introns
    - Exons

28. Identify the structures and functions of forms of RNA.

29. Describe the structures and actions of DNA and RNA viruses.

30. Relate the development of biotechnology to historical and classical applications.
    - Historical
      Examples: early agricultural practices, fermentation of foods and beverages
    - Classical
      Examples: industrialized fermentation, antibiotic production

31. Differentiate major areas in modern biotechnology.
    - Forensics and DNA profiling
    - Plant biotechnology
    - Animal biotechnology
    - Microbial biotechnology
    - Marine biotechnology

32. Explain the process used with recombinant DNA.
    - Cloning
    - Vectors
    - DNA sequencing
    - Isolation of DNA segments
    - Hybridization

33. Explain the development of the Human Genome project.
    - Background of the project
    - Ethical, social, and legal implications

34. Discuss medical uses of gene therapy.
    - Delivery methods
      Example: viral and nonviral delivery methods
    - Vaccines
    - Tissue engineering
    - Antibody engineering

GEOLOGY ELECTIVE CORE

Geology helps students clarify their understanding of the solid Earth (lithosphere) and the dynamic processes that have shaped and continue to shape it. In Geology, students conduct field and laboratory investigations, use scientific methods during investigations, and make informed decisions based on critical thinking and problem solving. Topics emphasized include plate tectonics, the Earth's materials, geologic dating, internal and external geological processes, and hydrology.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Geology curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. A recommended prerequisite science course is Physical Science or Chemistry. The minimum required content comprises the Core of an elective introductory Geology course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments and equipment.
   Example: wearing protective goggles when performing fracture tests

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables.
   Examples: calculating earthquake magnitude, measuring temperature, determining porosity in minerals

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Identify the advantages and disadvantages of widespread use of and reliance on technology in geology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning in geology and related fields.
    Examples: Internet usage, online/distance learning

15. Interpret the effects of technology in daily geologic applications.
    Examples: Global Positioning Systems (GPS), Geographic Information Systems (GIS), seismology in oil exploration, radioactive dating of rock

16. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

DYNAMIC EARTH

17. Describe the components of the lithosphere based on empirical scientific evidence.
    - Crust
    - Asthenosphere
    - Mantle
    - Outer Core
    - Inner Core

18. Describe the importance of the Earth's gravitational and magnetic fields to the study of geology.

19. Trace the scientific development of the idea of continental drift and the resulting theory of plate tectonics.

20. Describe the development of the scientific principle of uniformitarianism and its implications in geology.

21. Understand the origin and evolution of the continents.

22. Explain natural phenomena that shape the surface of the Earth.
    - Rock cycles
    - Plate motion and interactions
    - Erosion and deposition
    - Volcanism
    - Earthquakes

23. Distinguish between the Mercalli and Richter scales.

24. Compare the topography of the seafloor to that of land.

25. Explain the process of mountain building (orogenesis).

26. Relate the concept of equilibrium to geologic processes.

27. Explain the role of the lithosphere in biogeochemical cycles.
    Example: dissolution and precipitation of limestone in stalactite/stalagmite formation

28. Distinguish among rocks, minerals, and chemical elements.

29. Differentiate silicate from carbonate minerals.

30. Classify rocks according to how they are formed during a rock cycle.
    - Sedimentary
    - Igneous
    - Metamorphic

31. Describe factors that influence formation of different rock types.
    - Depth of formation
    - Rate of cooling
    - Mineral composition

32. Understand the concept of geologic time within the framework of the geologic time scale.
    - Relative dating methods
    - Absolute dating methods

33. Describe how physical continuity, similarity of rock types, and fossil comparison are used to identify correlation of widely-dispersed rock formations.

34. Identify similarities and differences among clastic, chemical, and organic sedimentary rocks.

35. Explain how the formation of sedimentary rock serves to produce a record of evolutionary change, both biologic and geologic.

36. Understand the concept of deformation.
    - Strike and dip
    - Folds
    - Joints
    - Faults

37. Classify igneous rocks based on mineral composition and texture.

38. Describe the characteristics of intrusive structures.
    - Dikes
    - Stocks
    - Sills
    - Laccoliths
    - Plutons
    - Batholiths

39. Explain factors that control the texture and composition of metamorphic rock.

40. Relate metamorphic and hydrothermal phenomena to tectonic activity.

41. Explain the relationships among weathering (physical/mechanical and chemical) and erosion of rocks and soil types.

42. Discuss factors influencing mass wasting.
    - Slope angle
    - Weathering and climate
    - Water content
    - Vegetation
    - Overloading

43. Differentiate among various types of mass wasting.
    - Falls
    - Slides
    - Flows
    - Complex movements

44. Explain the hydrologic cycle.

45. Identify the characteristics of a local watershed.
    - Average annual rainfall
    - Run-off patterns
    - Aquifers
    - Location of river basins
    - Surface water reservoirs

46. Analyze factors that impact watersheds.
    - Floods
    - Droughts
    - Urban development
    - Industrialization
    - Irrigation

47. Analyze the physical characteristics of fresh and/or salt water.
    - Salinity
    - Solubility
    - Heat capacity
    - Colligative properties
    - Density
    - Turbidity

48. Analyze the effects on coastlines, bays, and estuaries of tides, tidal bores/storm surges, longshore currents, and tsunamis.

MARINE BIOLOGY ELECTIVE CORE

Marine Biology is intended to provide students with advanced studies in Biology within the context of the marine environment. While emphasis is primarily on living systems, oceanography and aspects of marine water chemistry are important components of the Core. Also studied are comparative anatomy and physiology of freshwater and saltwater organisms' classification, biodiversity, interdependence within marine biomes, and human and natural impacts on marine systems.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Marine Biology curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. The recommended prerequisite science courses are Biology and Physical Science or Biology and Chemistry. The minimum required content comprises the Core of an elective introductory Marine Biology course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
   Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
   - Observing
   - Classifying
   - Measuring with appropriate units and significant figures
   - Inferring
   - Predicting
   - Solving problems
   - Interpreting data
   - Designing experiments
   - Formulating hypotheses
   - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
   Example: calculate mean, median, and mode from sample data

9. Solve for unknown quantities by manipulating variables.
   Example: salinity and pressure gradients

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology in the marine sciences.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning in marine biology.
    Examples: Internet usage, online/distance learning courses, databases

15. Identify the uses of technology in daily applications in marine sciences.
    Examples: water quality analysis, sonar, satellite mapping/tracking

16. Collect data and construct graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

The Cell

17. Identify the cellular basis for living systems.
    - Organic compounds in living processes
    - Relationships among cell structure, function, and organization in prokaryotes and eukaryotes
    - Process by which cells undergo diversification

DIVERSITY AND ADAPTATIONS

Biological Evolution

18. Classify different aquatic organisms using dichotomous keys.

19. Discuss the modern scientific theory of evolution as it relates to ocean life.
    - Various ocean drifters
      Examples: phytoplankton, zooplankton
    - Marine invertebrates
      Examples: protozoa, porifera, cnidaria, ctenophora, platyhelminthes, nemertina, nematoda, rotifera, bryozoa, chaetognatha, mollusca, annelida, arthropoda, protochordata
    - Marine vertebrates
      Examples: fishes–agnatha, chondricthyes, osteichthyes;
      other marine vertebrates–reptiles, birds, amphibians, mammals

ORGANISMS AND ENVIRONMENTS

Interdependence of Organisms

20. Differentiate among freshwater, brackish water, and saltwater ecosystems.

21. Describe the components of the major marine ecosystems.
    - Estuaries
      Examples: salt marsh communities, mud flat communities, oyster reef communities, sea grass bed communities
    - Sandy beach communities
    - Coral reefs
    - Deep ocean communities

22. Evaluate patterns and interrelationships among producers, consumers, and decomposers in an aquatic ecosystem.

23. Identify interdependence of organisms in an aquatic environment.
    Examples: pond, river, lake, ocean, aquifer

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

Matter, Energy, and Organization in Living Systems

24. Describe physical and geographical characteristics of the oceans.
    - Cycles of elements
      Examples: carbon, oxygen, nitrogen, phosphorus, silicon
    - Chemical composition of water
      Examples: dissolved salts, dissolved gases, dissolved nutrients, toxins
    - Topography of ocean floor, continental drift plate tectonics, sea level (rise and fall)
    - Wave motions, tsunami, tides, currents, depth/pressure

25. Relate the principles of fluid dynamics including Archimedes', Bernoulli's, and Pascal's principles and hydrostatic pressure within an aquatic environment.
    Examples: upwelling, compression/decompression, swimming

26. Discuss human influence on marine environments.
    - Marine pollution
      Examples: point and nonpoint sources of pollution, oil spills, airborne particles that fall into oceans
    - Fisheries management
      Examples: major fishery regions of the world; marine food species; mariculture of shrimp, oysters, crabs, finfish; overfishing
    - Implications of changing global weather patterns
      Examples: desertification, global warming, El Niño, La Niña

ZOOLOGY ELECTIVE CORE

The Zoology Core builds on the Biology Core with added emphasis on animal taxa, basic body plans, symmetry, and behavior. There is also emphasis on animal genetics including present and future applications of the Human Genome Project. Use of equipment provided by Alabama Science in Motion (ASIM) is recommended, particularly the gel electrophoresis equipment used for DNA studies. The emerging field of Bioethics can provide information on the proper care and ethical treatment of laboratory animals. Laboratory investigations should include dissection as well as computer simulations to provide students with adequate exposure to the comparative anatomy of representative animal species. Field studies encourage student interest and provide a means to study animals in their natural surroundings.

The Core itself is not intended to serve as the entire curriculum of any course. Teachers are encouraged to expand the Zoology curriculum beyond the limits of this Core Content, accommodating specific community interests and utilizing unique local resources. Courses developed from this Core should encourage critical thinking, use of the scientific method, integration of technology, and application of knowledge and skills learned to practical questions/problems. Safe field and laboratory investigations should be used in instruction to the maximum extent possible to illustrate scientific concepts and principles and support inquiry instruction. The recommended prerequisite science course for the Zoology Core is Biology. The minimum required content comprises the Core of an elective introductory Zoology course.

Minimum Required Content: Scientific Skills

PROCESS AND APPLICATION

Students will:

1. Understand fundamental assumptions about the universe upon which the scientific enterprise is based.
    - Concern with natural phenomena
    - Discoverable and understandable operation of the universe
    - Linking of natural causes with natural effects
    - Consistent and predictable operation of the universe

2. Discuss science as a body of knowledge and an investigative process.
    - Unified, open-ended structure of observations set in a testable framework of ideas
    - Common purpose and philosophy among the science disciplines
    - Limited scope and certainty
    - Simple solutions, comprehensive results, clearest and reliable explanations, accurate basis for predictions

3. Conduct scientific investigations systematically.
    - Identifying and framing the question carefully
    - Forming a hypothesis
    - Identifying and managing variables effectively
    - Developing a practical and logical procedure
    - Presenting conclusions based on investigation/previous research

4. Exhibit behaviors appropriate to the scientific enterprise consistently.
    Examples: curiosity, creativity, integrity, patience, skepticism, logical reasoning, attention to detail, openness to new ideas

5. Demonstrate correct care and safe use of instruments, equipment, and living organisms.
    Examples: identifying allergies associated with animals, not using wild animals in labs

6. Demonstrate the ability to choose, construct, and/or assemble appropriate equipment for scientific investigations.

7. Apply critical and integrated science thinking skills.
    - Observing
    - Classifying
    - Measuring with appropriate units and significant figures
    - Inferring
    - Predicting
    - Solving problems
    - Interpreting data
    - Designing experiments
    - Formulating hypotheses
    - Communicating

8. Use mathematical models, simple statistical models, and graphical models to express patterns and relationships determined from sets of scientific data.
    Example: calculate mean, median, and mode from sample data

9. Solve for unknowns by manipulating variables.
    Examples: population, density sampling

10. Use written and oral communication skills to present and explain scientific phenomena and concepts individually or in collaborative groups using technical and non-technical language.
    Examples: laboratory reports, journal entries, computer-based slide show presentations, daily log reports, student project presentations

11. Choose appropriate technology to retrieve relevant information from the Internet such as electronic encyclopedias, indices, and databases.

12. Analyze the advantages and disadvantages of widespread use of and reliance on technology.

13. Practice responsible use of technology systems, information, and software such as following copyright laws.

14. Evaluate technology-based options for lifelong learning.
    Examples: Internet usage, online/distance learning

15. Collaborate with peers, experts, and others to continue to a science knowledge base using technology to synthesize and present work.

16. Identify the uses of technology in zoological applications.
    Examples: genetic engineering, animal transport, tracking devices

17. Collect data and construct and analyze graphs, tables, and charts using tools such as computer-based or calculator-based probeware.

Minimum Required Content: Scientific Knowledge

STRUCTURE AND FUNCTION OF LIVING SYSTEMS

The Cell

18. Analyze the relationships among cell structure, function, and organization in the Kingdom Animalia and in animal-like Protista (Protozoans).

19. Analyze the process by which cells become specialized even though DNA is identical in every cell.
    Examples: muscle cells, nerve cells, skin cells

Matter, Energy, and Organization in Living Systems

20. Distinguish among three main types of body plans.
    - Acoelomate
    - Pseudocoelomate
    - Coelomate

21. Identify types of body symmetry
    - Radial
    - Bilateral
    - Asymmetrical

22. Distinguish between vertebrates and invertebrates.

23. Discuss energy flow and productivity in ecosystems.

DIVERSITY AND ADAPTATIONS

Biological Evolution

24. Identify animal species by comparing similarities in molecular, anatomical, and fossil evidence.

25. Use taxonomic groupings of nine phyla to differentiate structures, physiology, and life cycles of animals.
    - Porifera
    - Cnidaria
    - Mollusca
    - Worm phyla
      Examples: Platyhelminthes, Nematoda, Annelida
    - Arthropoda
    - Echinodermata
    - Chordata
      Examples: tunicates, fish, amphibians, reptiles, birds, mammals

26. Analyze the Hardy-Weinberg principle as a model to test the occurrence of evolution by natural selection.
    - Migration
    - Selective breeding
    - Genetic drift
    - Mutation
    - Population size

HEREDITY AND REPRODUCTION

Molecular Basis of Heredity

27. Recognize heritable traits of animals.
    - Physical structure
    - Chemical composition
      Examples: DNA sequence, protein structure
    - Behavior

28. Describe important areas of animal genetics.
    - Mendelian genetics (phenotype)
    - Molecular genetics (genotype)
    - Genetic engineering
      Examples: cloning, stem cell research, transgenic animals, gene transfer

29. Predict future applications of knowledge gained from the Human Genome project.
    Example: genetic alteration of species *Pseudomonas aeruginosa* (a major cause of infection in patients with cystic fibrosis)

ORGANISMS AND ENVIRONMENTS

Interdependence of Organisms

30. Relate factors used to distinguish species.
    - Reproductive isolation
    - Behavioral differences
    - Differences in protein structure
    - Differences in DNA sequence

31. Analyze a field study of animal behavior patterns in relation to their niche in a given habitat.

32. Explain the different relationships among living organisms.
    - Competition
    - Symbiosis
      Examples: mutualism, commensalism, parasitism
    - Producer/consumer/decomposer
      Examples: autotrophs, heterotrophs
    - Predator/prey
      Examples: mimicry, camouflage