GRADE 10

In tenth grade, *students examine scientific theories and master both their field and controlled investigative skills. They develop physical, conceptual, and mathematical models to represent and investigate objects, events, systems, and processes. Students infer and make predictions based on scientific evidence and then apply their skills and knowledge to new situations.*

EALR 1 — SYSTEMS: The student knows and applies scientific concepts and principles to understand the properties, structures, and changes in physical, earth/space, and living systems.

Component 1.1 Properties: Understand how properties are used to identify, describe, and categorize substances, materials, and objects and how characteristics are used to categorize living things.

Physical Systems

Properties of Substances

1.1.1 Understand the atomic nature of matter, how it relates to physical and chemical properties and serves as the basis for the structure and use of the periodic table. W

- Identify an unknown substance using the substance's physical and chemical properties.
- Explain and predict the behavior of a substance based upon the substance's atomic structure, physical properties, and chemical properties.
- Describe the properties of electrons, protons, and neutrons (i.e., electrons have negative charge and very little mass, protons have positive charge and much mass, neutrons have neutral charge and the same mass as protons).
- Explain how changing the number of electrons, neutrons, and protons of an atom affects that atom, including atomic name, number, and placement on the periodic table.
- Explain the similar properties of elements in a vertical column (groups or families) of the periodic table.
- Predict the properties of an element based on the element's location (groups or families) on the periodic table.

Wave Behavior

1.1.3 Analyze sound waves, water waves, and light waves using wave properties, including frequency and energy. Understand wave interference. W

- Describe the relationship between the wave properties of amplitude and frequency and the energy of a wave (e.g., loud vs. soft sound, high vs. low pitch sound, bright vs. dim light, blue light vs. red light).

- Explain the relationship between a wave's speed and the properties of the substance through which the wave travels (e.g., all sound regardless of loudness and pitch travels at the same speed in the same air; a wave changes speed only when traveling from one substance to another).
- Predict and explain what happens to the pitch of sound and color of light as the wave frequency increases or decreases.
- Compare the properties of light waves, sound waves, and water waves.
- Describe the effects of wave interference (constructive and destructive).

Forms of Energy

1.1.4 Analyze the forms of energy in a system, subsystems, or parts of a system. W

- Explain the forms of energy present in a system (i.e., thermal energy, sound energy, light energy, electrical energy, kinetic energy, potential energy, chemical energy, and nuclear energy).
- Compare the potential and/or kinetic energy of parts of systems at various locations or times (i.e., kinetic energy is an object's energy of motion; potential energy is an object's energy of position).
- Measure and describe the thermal energy of a system, subsystem, and/or parts of a system in terms of molecular motion (temperature) and energy from a phase change (e.g., observe, measure, and record temperature changes over time while heating ice to boiling water).

Characteristics of Living Matter

1.1.6 Analyze structural, cellular, biochemical, and genetic characteristics in order to determine the relationships among organisms. W

- Analyze the relationship among organisms based on their shared physical, biochemical, genetic, and cellular characteristics and functional processes.

Component 1.2 Structures: Understand how components, structures, organizations, and interconnections describe systems.

Systems Structure

Structure of Physical Earth/Space and Living Systems

1.2.1 Analyze how systems function, including the inputs, outputs, transfers, transformations, and feedback of a system and its subsystems. W

- Explain the interconnections between a system's parts or subsystems.

Energy Transfer and Transformation

1.2.2 Analyze energy transfers and transformations within a system, including energy conservation.

- Distinguish conditions likely to result in transfers or transformations of energy from one part of a system to another (e.g., a temperature difference may result in the flow of thermal energy from a hot area to a cold area).
- Describe what happens in terms of energy conservation to a system's total energy as energy is transferred or transformed (e.g., energy is never "lost," the sum of kinetic and potential energy remains somewhat constant).
- Explain the relationship between the motion of particles in a substance and the transfer or transformation of thermal and electrical energy (e.g., conduction of thermal and electrical energy

as particles collide or interact, convection of thermal energy as groups of particles move from one place to another, and light waves transforming into thermal energy).
- Explain how or whether a phase change, a chemical reaction, or a nuclear reaction absorbs or releases energy in a system (e.g., water vapor forming rain or snow releases energy; water molecules speed up as they absorb energy until the molecules gain enough energy to become water vapor).

Structure of Matter

1.2.3 Understand the structure of atoms, how atoms bond to form molecules, and that molecules form solutions. W

- Describe molecules forming a solution (e.g., salt added to water dissolves, forming a salt water solution, until saturation when no more salt will dissolve).
- Describe how to separate mixtures and or solutions of several different kinds of substances (e.g., sand, sugar, iron filings).
- Describe the structure of atoms in terms of protons and neutrons forming the nucleus, which is surrounded by electrons (e.g., a helium atom usually has a nucleus formed by 2 protons and 2 neutrons, which is surrounded by 2 electrons).
- Describe how atoms bond to form molecules in terms of transferring and/or sharing electrons (e.g., sodium atoms transfer an electron to chlorine atoms to form salt).

Earth and Space Systems

Components of the solar system and beyond (Universe)

1.2.5 Understand that the Solar System is in a galaxy in a universe composed of an immense number of stars and other celestial bodies. W

- Describe how the Solar System is part of the Milky Way Galaxy.
- Compare how stars and other celestial bodies (at least 100 billion) are similar and different from each other (i.e., size, composition, distance from the Earth, temperature, age, source of light, and movement in space).
- Describe how other galaxies and other celestial bodies appear from Earth.

Living Systems

Structure and Organization of Living Systems

1.2.6 Understand cellular structures, their functions, and how specific genes regulate these functions. W

- Describe cellular structures that allow cells to extract and use energy from food, eliminate wastes, and respond to the environment (e.g., every cell is covered by a membrane that controls what goes into and out of the cell).
- Describe how DNA molecules are long chains linking four kinds of smaller molecules, whose sequence encodes genetic information.
- Describe how genes (DNA segments) provide instructions for assembling protein molecules in cells.
- Describe how proteins control life functions (e.g., the proteins myosin and actin interact to cause muscular contraction; the protein hemoglobin carries oxygen in some organisms).

Molecular Basis of Heredity

1.2.7 Understand how genetic information (DNA) in the cell is encoded at the molecular level and provides genetic continuity between generations. W

- Describe the role of chromosomes in reproduction (i.e., parents pass on chromosomes, which contain genes, to their offspring).
- Describe the possible results from mutation in DNA (e.g., only mutations in sex cells can be passed to offspring; mutations in other cells can only be passed to descendant cells).
- Describe how organisms pass on genetic information via asexual life cycles (i.e., the replication of genes in asexual reproduction results in the same gene combinations in the offspring as those of the parent).
- Describe how organisms pass on genetic information via sexual life cycles (i.e., the sorting and the recombination of genes in sexual reproduction results in a great variety of gene combinations and resultant variations in the offspring of any two parents).

Human Biology

1.2.8 Analyze how human organ systems regulate growth, development, and life functions. W

- Name the structural and functional characteristics of human organ systems, including the endocrine, immune, nervous, reproductive, and skin systems.
- Describe how the human body maintains relatively constant internal conditions (e.g., temperature, acidity, and blood sugar).
- Explain how human organ systems help maintain human health.
- Describe the role of human organ systems during human growth and development.
- Compare the structure and function of a human body system or subsystem to a nonliving system (e.g., human joints to hinges, enzyme and substrate to interlocking puzzle pieces).

Component 1.3 Changes: Understand how interactions within and among systems cause changes in matter and energy.

Earth and Space Systems

Interactions in the Solar System and Beyond (Universe)

1.3.7 Understand how stars, solar systems, galaxies, and the universe were formed and how these systems continue to evolve. W

- Explain phenomena caused by the regular and predictable motions of planets and moons in the Solar System.
- Describe how the Solar System formed.
- Describe that the Solar System is part of the Milky Way Galaxy and how the Milky Way and other galaxies appear from Earth.
- Describe the formation and life cycle of stars.
- Describe the properties of different stars (e.g., size, temperature, age, formation, energy production).
- Describe how the Big Bang theory explains the observed properties of the universe (e.g., expansion, evolution, structures, element generation by fusion).

Biological Evolution

1.3.9 Analyze the scientific evidence used to develop the theory of biological evolution and the concepts of natural selection, speciation, adaptation, and biological diversity. W

- Describe the factors that drive natural selection (i.e., overproduction of offspring, genetic variability of offspring, finite supply of resources, competition for resources, and differential survival).
- Explain how natural selection and adaptation lead to organisms well suited for survival in particular environments.
- Examine or characterize the degree of evolutionary relationship between organisms based on biochemical, genetic, anatomical, or fossil record similarities and differences.

EALR 2 — INQUIRY: The student knows and applies the skills, processes, and nature of scientific inquiry.

Component 2.1 Investigating Systems: Develop the knowledge and skills necessary to do scientific inquiry.

Investigating Systems

Questioning

2.1.1 Understand how to generate and evaluate questions that can be answered through scientific investigations. W

- Generate a new question that can be investigated with the same materials and/or data as a given investigation.
- Generate questions, and critique whether questions can be answered through scientific investigations.

Planning and Conducting Safe Investigations

2.1.2 Understand how to plan and conduct systematic and complex scientific investigations. W

- Make a hypothesis about the results of an investigation that includes a prediction with a cause-effect reason.
- Generate a logical plan for, and conduct, a systematic and complex scientific controlled investigation with the following attributes:
    - hypothesis (prediction with cause-effect reason)
    - appropriate materials, tools, and available computer technology
    - controlled variables
    - one manipulated variable
    - responding (dependent) variable
    - gather, record, and organize data using appropriate units, charts, and/or graphs
    - multiple trials
    - experimental control condition when appropriate
    - additional validity measures
- Generate a logical plan for a simple field investigation with the following attributes:

    - identify multiple variables
    - select observable or measurable variables related to the investigative question
- Identify and explain safety requirements that would be needed in an investigation.

Explaining

2.1.3 Synthesize a revised scientific explanation using evidence, data, and inferential logic. W

- Generate a scientific conclusion, including supporting data from an investigation, using inferential logic. (e.g., The fertilizer did help the plants grow faster, but had little effect on the number of seeds that germinated. With the fertilizer, the plants matured 35 days sooner than plants without the fertilizer. Almost all of the 30 seeds used germinated, 13 seeds in the fertilized soil and 14 seeds in the soil without fertilizer.)
- Describe a reason for a given conclusion using evidence from an investigation.
- Generate a scientific explanation of an observed phenomenon using given data.
- Predict and explain what logically might occur if an investigation lasted longer or changed.
- Explain the difference between evidence (data) and conclusions.
- Revise a scientific explanation to better fit the evidence and defend the logic of the revised explanation.
- Explain how scientific evidence supports or refutes claims or explanations of phenomena.

Modeling

2.1.4 Analyze how physical, conceptual, and mathematical models represent and are used to investigate objects, events, systems, and processes. W

- Compare how a model or different models represent the actual behavior of an object, event, system, or process.
- Evaluate how well a model describes or predicts the behavior of an object, event, system, or process.
- Create a physical, conceptual, and/or mathematical (computer simulation) model to investigate, predict, and explain the behavior of objects, events, systems, or processes (e.g., DNA replication).

Communicating

2.1.5 Apply understanding of how to report complex scientific investigations and explanations of objects, events, systems, and processes, and how to evaluate scientific reports. W

- Report observations of scientific investigations without making inferences.
- Summarize an investigation by describing:
    - reasons for selecting the investigative plan
    - materials used in the investigation
    - observations, data, results
    - explanations and conclusions in written, mathematical, oral, and information technology presentation formats
    - ramifications of investigations to concepts, principles, and theories
    - safety procedures used
- Describe the difference between an objective summary of data and an inference made from data.
- Compare the effectiveness of different graphics and tables to describe patterns, explanations, conclusions, and implications found in investigations.
- Critique a scientific report for completeness, accuracy, and objectivity.

Component 2.2 Nature of Science: Understand the nature of scientific inquiry.

Nature of Science

Intellectual Honesty

2.2.1 Analyze why curiosity, honesty, cooperation, openness, and skepticism are important to scientific explanations and investigations. W

- Explain why honesty ensures the integrity of scientific investigations (e.g., explanations in the absence of credible evidence, questionable results, conclusions or explanations inconsistent with established theories).
- Explain why a claim or a conclusion is flawed (e.g., limited data, lack of controls, weak logic).
- Explain why scientists are expected to accurately and honestly record, report, and share observations and measurements without bias.
- Explain why honest acknowledgement of the contributions of others and information sources are necessary (e.g., undocumented sources of information, plagiarism).
- Explain why peer review is necessary in the scientific reporting process.

Limitations of science and Technology

2.2.2 Analyze scientific theories for logic, consistency, historical and current evidence, limitations, and capacity to be investigated and modified. W

- Describe how a theory logically explains a set of facts, principles, concepts and/or knowledge.
- Describe a theory that best explains and predicts phenomena and investigative results.
- Explain how scientific theories are open to investigation and have the capacity to be modified.

Evaluating inconsistent results

2.2.3 Evaluate inconsistent or unexpected results from scientific investigations using scientific explanations. W

- Evaluate similar investigations with inconsistent or unexpected results.
- Explain whether sufficient data has been obtained to make an explanation or conclusion (e.g., reference previous and current research; incorporate scientific concepts, principles, and theories).
- Explain why results from a single investigation or demonstration are not conclusive about a phenomenon.

Evaluating Methods of Investigation

2.2.4 Analyze scientific investigations for validity of method and reliability of results. W

- Describe how the methods of an investigation ensured reliable results.
- Explain how to increase the reliability of the results of an investigation (e.g., repeating an investigation exactly the same way increases the reliability of the results).
- Describe how the methods of an investigation ensured validity (i.e., validity means that the investigation answered the investigative question with confidence; the manipulated variable caused the change in the responding or dependent variable).
- Explain the purpose of the steps of an investigation in terms of the validity of the investigation.

- Explain how to improve the validity of an investigation (e.g., control more variables, better measuring techniques, increased sample size, control for sample bias, include experimental control condition when appropriate, include a placebo group when appropriate).
- Explain an appropriate type of investigation to ensure reliability and validity for a given investigative question (e.g., descriptive, controlled, correlational, comparative, see Appendix D and Appendix E).

Evolution of Scientific Ideas

2.2.5 Understand how scientific knowledge evolves. W

- Explain how scientific inquiry results in new facts, evidence, unexpected findings, ideas, explanations, and revisions to current theories.
- Explain how results of scientific inquiry may change our understanding of the systems of the natural and constructed world.
- Explain how increased understanding of systems leads to new questions to be investigated.
- Explain how new ideas need repeated inquiries before acceptance.
- Use new tools to investigate a system to discover new facts about the system that lead to new ideas and questions.

EALR 3 — APPLICATION: The student knows and applies science concepts and skills to develop solutions to human problems in societal contexts.

Component 3.1 Designing Solutions: Apply knowledge and skills of science and technology to design solutions to human problems or meet challenges.

Designing Solutions

Identifying Problems

3.1.1 Analyze local, regional, national, or global problems or challenges in which scientific design can be or has been used to design a solution. W

- Explain how science and technology could be used to solve all or part of a human problem and vice versa (e.g., understanding the composition of an Earth material can be useful to humans, such as copper ore being used to make copper wire).
- Explain the scientific concept, principle, or process used in a solution to a human problem (e.g., understanding the effect of seismic waves on structures can be used to design buildings to withstand an earthquake).
- Explain how to scientifically gather information to develop a solution (e.g., perform a scientific investigation and collect data to establish the best materials to use in a solution to the problem).
- Describe an appropriate question that could lead to a possible solution to a problem.
- Describe a change that could improve a tool or a technology.

Designing and Testing Solutions

3.1.2 Evaluate the scientific design process used to develop and implement solutions to problems or challenges. W

- Research, propose, implement, and document the scientific design process used to solve a problem or challenge:
    - define the problem
    - scientifically gather information and collect empirical data
    - explore ideas
    - make a plan
    - list steps to do the plan
    - scientifically test solutions
    - document the scientific design process
- Evaluate possible solutions to the problem (e.g., describe how to clean up a polluted stream).
- Evaluate the reason(s) for the effectiveness of a solution to a problem or challenge.

Evaluation Potential Solutions

3.1.3 Evaluate consequences, constraints, and applications of solutions to a problem or challenge. W

- Explain the criteria to evaluate the solution(s) to a problem or challenge.
- Explain the effectiveness of the solution to the problem or challenge using scientific principles and concepts.
- Explain the consequences of the solution(s) to the problem or challenge (e.g., doubling the fertilizer will probably not double the plant growth and could cause harm to the ecosystem).
- Explain how to change a system to solve a problem or improve a solution to a problem.
- Compare and evaluate the effectiveness of different solutions to a problem or challenge based on criteria, using scientific concepts and principles.

Component 3.2 Science, Technology, and Society: Analyze how science and technology are human endeavors, interrelated to each other, society, the workplace, and the environment.

Science, Technology, and Society

All Peoples Contribute to Science and Technology

3.2.1 Analyze how scientific knowledge and technological advances discovered and developed by individuals and communities in all cultures of the world contribute to changes in societies.

- Compare the impacts of diverse cultures and individuals on science and technology.

Relationship of Science and Technology

3.2.2 Analyze how the scientific enterprise and technological advances influence and are influenced by human activity. W

- Describe how science and/or technology have led to a given social or economic development.
- Explain risks associated with investigations involving living things (e.g., drug trials on animals, testing of genetically engineered plants, release of African snails into the environment after experimentation).
- Identify the limits of scientific research in solving a given social, environmental, and/or economic problem.
- Compare advantages and/or disadvantages of using new technology or science in terms of ethics, politics, and environmental considerations.

- Explain the concept of proprietary discovery (e.g., patents on genes).

Careers and Occupations Using Science, Mathematics, and Technology

3.2.3 Analyze the scientific, mathematical, and technological knowledge, training, and experience needed for occupational/career areas of interest.

- Research and report on educational requirements associated with an occupation(s)/career(s) of interest.
- Examine the scientific, mathematical, and technological knowledge, training, and experience needed for occupational/career areas of interest.

Environmental and Resource Issues

3.2.4 Analyze the effects human activities have on Earth's capacity to sustain biological diversity. W

- Explain how the use of renewable and nonrenewable natural resources affects the sustainability of an ecosystem.
- Explain how human activities affect Earth's capacity to sustain biological diversity (e.g., global warming, ozone depletion).