Science Assessment Framework — **BOLD** eligible for CRT

Grade 11 — *Italics=Classroom Assessment Only*

Strand I: Scientific Thinking and Practice

Standard I: Understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

9-12 Benchmark I: Use accepted scientific methods to collect, analyze, and interpret data and observations and to design and conduct scientific investigations and communicate results.

1. **Describe the essential components of an investigation, including appropriate methodologies, proper equipment, and safety precautions.**
2. **Design and** *conduct* **scientific investigations that include:**
   - **testable hypotheses**
   - **controls and variables**
   - **methods to collect, analyze, and interpret data**
   - **results that address hypotheses being investigated**
   - **predictions based on results**
   - **re-evaluation of hypotheses and additional experimentation as necessary**
   - **error analysis.**
3. **Use appropriate technologies to collect, analyze, and communicate scientific data (e.g., computers, calculators, balances, microscopes).**
4. **Convey results of investigations using scientific concepts, methodologies, and expressions, including:**
   - **scientific language and symbols**
   - **diagrams, charts, and other data displays**
   - **mathematical expressions and processes (e.g., mean, median, slope, proportionality)**
   - **clear, logical, and concise communication**
   - **reasoned arguments.**
5. **Understand how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atom).**

9-12 Benchmark II: Understand that scientific processes produce scientific knowledge that is continually evaluated, validated, revised, or rejected.

1. **Understand how scientific processes produce valid, reliable results, including:**
   - **consistency of explanations with data and observations**
   - **openness to peer review**
   - **full disclosure and examination of assumptions**
   - **testability of hypotheses**
   - **repeatability of experiments and reproducibility of results.**
2. **Use scientific reasoning and valid logic to recognize:**
   - **faulty logic**
   - **cause and effect**
   - **the difference between observation and unsubstantiated inferences and conclusions**
   - **potential bias.**
3. **Understand how new data and observations can result in new scientific knowledge.**
4. **Critically analyze an accepted explanation by reviewing current scientific knowledge.**
5. **Examine investigations of current interest in science (e.g., superconductivity, molecular machines, age of the universe).**
6. **Examine the scientific processes and logic used in investigations of past events (e.g., using data from crime scenes, fossils), investigations that can be planned in advance but are only done once (e.g., expensive or time-consuming experiments such as medical clinical trials), and investigations of phenomena that can be repeated easily and frequently.**

9-12 Benchmark III: Use mathematical concepts, principles, and expressions to analyze data, develop models, understand patterns and relationships, evaluate findings, and draw conclusions.

1. **Create multiple displays of data to analyze and explain the relationships in scientific investigations.**
2. **Use mathematical models to describe, explain, and predict natural phenomena.**
3. **Use technologies to quantify relationships in scientific hypotheses (e.g., calculators, computer spreadsheets and databases, graphing software, simulations, modeling).**
4. **Identify and apply measurement techniques and consider possible effects of measurement errors.**
5. **Use mathematics to express and establish scientific relationships (e.g., scientific notation, vectors, dimensional analysis).**

Strand II: The Content of Science

Standard I (Physical Science): Understand the structure and properties of matter, the characteristics of energy.

9-12 Benchmark I: Understand the properties, underlying structure, and reactions of matter.

Properties of Matter

1. **Classify matter in a variety of ways (e.g., element, compound, mixture; solid, liquid, gas; acidic, basic, neutral).**
2. **Identify, measure, and use a variety of physical and chemical properties (e.g., electrical conductivity, density, viscosity, chemical reactivity, pH, melting point).**
3. **Know how to use properties to separate mixtures into pure substances (e.g., distillation, chromatography, solubility).**
4. **Describe trends in properties (e.g., ionization energy or reactivity as a function of location on the periodic table, boiling point of organic liquids as a function of molecular weight).**

Structure of Matter

5. **Understand that matter is made of atoms and that atoms are made of subatomic particles.**
6. **Understand atomic structure, including:**
   - **most space occupied by electrons**
   - **nucleus made of protons and neutrons**
   - **isotopes of an element**
   - **masses of proton and neutron 2000 times greater than mass of electron**
   - **atom held together by proton-electron electrical forces.**
7. **Explain how electrons determine the properties of substances by:**
   - **interactions between atoms through transferring or sharing valence electrons**
   - **ionic and covalent bonds**
   - **the ability of carbon to form a diverse array of organic structures.**
8. **Make predictions about elements using the periodic table (e.g., number of valence electrons, metallic character, reactivity, conductivity, type of bond between elements).**
9. **Understand how the type and arrangement of atoms and their bonds determine macroscopic properties (e.g., boiling point, electrical conductivity, hardness of minerals).**
10. **Know that states of matter (i.e., solid, liquid, gas) depend on the arrangement of atoms and molecules and on their freedom of motion.**
11. **Know that some atomic nuclei can change, including:**
    - **spontaneous decay**
    - **half-life of isotopes**
    - **fission**
    - **fusion (e.g., the sun)**
    - **alpha, beta, and gamma radiation**

Chemical Reactions

12. **Know that chemical reactions involve the rearrangement of atoms, and that they occur on many timescales (e.g., picoseconds to millennia).**
13. **Understand types of chemical reactions (e.g., synthesis, decomposition, combustion, redox,**

neutralization) and identify them as exothermic or endothermic.

14. Know how to express chemical reactions with balanced equations that show:

- **conservation of mass**
- **products of common reactions.**

15. Describe how the rate of chemical reactions depends on many factors that include temperature, concentration, and the presence of catalysts.

9-12 Benchmark II: Understand the transformation and transmission of energy and how energy and matter interact.

Energy Transformation and Transfer

1. **Identify different forms of energy, including kinetic, gravitational (potential), chemical, thermal, nuclear, and electromagnetic.**
2. **Explain how thermal energy (heat) consists of the random motion and vibrations of atoms and molecules and is measured by temperature.**
3. **Understand that energy can change from one form to another (e.g., changes in kinetic and potential energy in a gravitational field, heats of reaction, hydroelectric dams) and know that energy is conserved in these changes.**
4. **Understand how heat can be transferred by conduction, convection, and radiation, and how heat conduction differs in conductors and insulators.**
5. **Explain how heat flows in terms of the transfer of vibrational motion of atoms and molecules from hotter to colder regions.**
6. **Understand that the ability of energy to do something useful (work) tends to decrease (and never increases) as energy is converted from one form to another.**

Interactions of Energy and Matter

7. **Understand that electromagnetic waves carry energy that can be transferred when they interact with matter.**
8. **Describe the characteristics of electromagnetic waves (e.g., visible light, radio, microwave, X-ray, ultraviolet, gamma) and other waves (e.g., sound, seismic waves, water waves), including:**
   - **origin and potential hazards of various forms of electromagnetic radiation**
   - **energy of electromagnetic waves carried in discrete energy packets (photons) whose energy is inversely proportional to wavelength.**
9. **Know that each kind of atom or molecule can gain or lose energy only in discrete amounts.**
10. **Explain how wavelengths of electromagnetic radiation can be used to identify atoms, molecules, and the composition of stars.**
11. **Understand the concept of equilibrium (i.e., thermal, mechanical, and chemical).**

9-12 Benchmark III: **Understand the motion of objects and waves, and the forces that cause them**

Forces

1. **Know that there are four fundamental forces in nature: gravitation, electromagnetism, weak nuclear force, and strong nuclear force.**
2. **Know that every object exerts gravitational force on every other object, and how this force depends on the masses of the objects and the distance between them.**
3. **Know that materials containing equal amounts of positive and negative charges are electrically neutral, but that a small excess or deficit of negative charges produces significant electrical forces.**
4. **Understand the relationship between force and pressure, and how the pressure of a volume of gas depends on the temperature and the amount of gas.**

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Motion

8. **Apply Newton's Laws to describe and analyze the behavior of moving objects, including:**
   - **displacement, velocity, and acceleration of a moving object**
   - **Newton's Second Law, *F = ma* (e.g., momentum and its conservation, the motion of an object falling under gravity, the independence of a falling object's motion on mass)**
   - **circular motion and centripetal force.**
9. **Describe relative motion using frames of reference.**
10. **Describe wave propagation using amplitude, wavelength, frequency, and speed.**
11. **Explain how the interactions of waves can result in interference, reflection, and refraction.**
12. **Describe how waves are used for practical purposes (e.g., seismic data, acoustic effects, Doppler Effect).**

Strand II: The Content of Science

Standard II (Life Science): Understand the properties, structures, and processes of living things and the interdependence of living things and their environments**.**

9-12 Benchmark I: Understand how the survival of species depends on biodiversity and on complex interactions, including the cycling of matter and the flow of energy.

Ecosystems

1. **Know that an ecosystem is complex and may exhibit fluctuations around a steady state or may evolve over time.**
2. **Describe how organisms cooperate and compete in ecosystems (e.g., producers, decomposers, herbivores, carnivores, omnivores, predator-prey, symbiosis, mutualism).**
3. **Understand and describe how available resources limit the amount of life an ecosystem can support (e.g., energy, water, oxygen, nutrients).**
4. **Critically analyze how humans modify and change ecosystems (e.g., harvesting, pollution, population growth, technology).**

Energy Flow in the Environment

5. **Explain how matter and energy flow through biological systems (e.g., organisms, communities, ecosystems), and how the total amount of matter and energy is conserved but some energy is always released as heat to the environment.**
6. **Describe how energy flows from the sun through plants to herbivores to carnivores and decomposers.**
7. **Understand and explain the principles of photosynthesis (i.e., chloroplasts in plants convert light energy, carbon dioxide, and water into chemical energy).**

Biodiversity

8. **Understand and explain the hierarchical classification scheme (i.e., domain, kingdom, phylum, class, order, family, genus, species), including:**
   - **classification of an organism into a category**
   - **similarity inferred from molecular structure (DNA) closely matching classification based on anatomical similarities**
   - **similarities of organisms reflecting evolutionary relationships.**

9. Understand variation within and among species, including:
- **mutations and genetic drift**
- **factors affecting the survival of an organism**
- **natural selection.**

9-12 Benchmark II: Understand the genetic basis for inheritance and the basic concepts of biological evolution.

Genetics

1. Know how DNA carries all genetic information in the units of heredity called genes, including:
- **the structure of DNA (e.g., subunits A, G, C, T)**
- **information-preserving replication of DNA**
- **alteration of genes by inserting, deleting, or substituting parts of DNA.**

2. Use appropriate vocabulary to describe inheritable traits (i.e., genotype, phenotype).
3. Explain the concepts of segregation, independent assortment, and dominant/recessive alleles.
4. Identify traits that can and cannot be inherited.
5. Know how genetic variability results from the recombination and mutation of genes, including:
- **sorting and recombination of genes in sexual reproduction result in a change in DNA that is passed on to offspring**
- **radiation or chemical substances can cause mutations in cells, resulting in a permanent change in DNA.**

6. Understand the principles of sexual and asexual reproduction, including meiosis and mitosis.
7. Know that most cells in the human body contain 23 pairs of chromosomes including one pair that determines sex, and that human females have two X chromosomes and human males have an X and a Y chromosome.

Biological Evolution

8. Describe the evidence for the first appearance of life on Earth as one-celled organisms, over 3.5 billion years ago, and for the later appearance of a diversity of multicellular organisms over millions of years.
9. Critically analyze the data and observations supporting the conclusion that the species living on Earth today are related by descent from the ancestral one-celled organisms.
10. Understand the data, observations, and logic supporting the conclusion that species today evolved from earlier, distinctly different species, originating from the ancestral one-celled organisms.
11. Understand that evolution is a consequence of many factors, including the ability of organisms to reproduce, genetic variability, the effect of limited resources, and natural selection.
12. Explain how natural selection favors individuals who are better able to survive, reproduce, and leave offspring.
13. Analyze how evolution by natural selection and other mechanisms explains many phenomena including the fossil record of ancient life forms and similarities (both physical and molecular) among different species.

9-12 Benchmark III: Understand the characteristics, structures, and functions of cells.

Structure and Function

1. Know that cells are made of proteins composed of combinations of amino acids.
2. Know that specialized structures inside cells in most organisms carry out different functions, including:
- **parts of a cell and their functions (e.g., nucleus, chromosomes, plasma, and mitochondria)**
- **storage of genetic material in DNA**

- **similarities and differences between plant and animal cells**
- **prokaryotic and eukaryotic cells.**

3. **Describe the mechanisms for cellular processes (e.g., energy production and storage, transport of molecules, waste disposal, synthesis of new molecules).**
4. **Know how the cell membrane controls which ions and molecules enter and leave the cell based on membrane permeability and transport (i.e., osmosis, diffusion, active transport, passive transport).**
5. **Explain how cells differentiate and specialize during the growth of an organism, including:**
   - **differentiation, regulated through the selected expression of different genes**
   - **specialized cells, response to stimuli (e.g., nerve cells, sense organs).**
6. **Know that DNA directs protein building (e.g., role of RNA).**

Biochemical Mechanisms

7. **Describe how most cell functions involve chemical reactions, including:**
   - **promotion or inhibition of biochemical reactions by enzymes**
   - **processes of respiration (e.g., energy production, ATP)**
   - **communication from cell to cell by secretion of a variety of chemicals (e.g., hormones).**

Strand II: The Content of Science

Standard III (Earth and Space Science): Understand the structure of Earth, the solar system, and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

9-12 Benchmark I: Examine the scientific theories of the origin, structure, contents, and evolution of the solar system and the universe, and their interconnections.

1. **Understand the scale and contents of the universe, including:**
   - **range of structures from atoms through astronomical objects to the universe**
   - **objects in the universe such as planets, stars, galaxies, and nebulae.**
2. **Predict changes in the positions and appearances of objects in the sky (e.g., moon, sun) based on knowledge of current positions and patterns of movements (e.g., lunar cycles, seasons).**
3. **Understand how knowledge about the universe comes from evidence collected from advanced technology (e.g., telescopes, satellites, images, computer models).**
4. **Describe the key observations that led to the acceptance of the Big Bang theory and that the age of the universe is over 10 billion years.**
5. **Explain how objects in the universe emit different electromagnetic radiation and how this information is used.**
6. **Describe how stars are powered by nuclear fusion, how luminosity and temperature indicate their age, and how stellar processes create heavier and stable elements that are found throughout the universe.**
7. **Examine the role that New Mexico research facilities play in current space exploration (e.g., Very Large Array, Goddard Space Center).**

9-12 Benchmark II: Examine the scientific theories of the origin, structure, energy, and evolution of Earth and its atmosphere, and their interconnections

Characteristics and Evolution of Earth

1. **Describe the characteristics and the evolution of Earth in terms of the geosphere, the hydrosphere, the atmosphere, and the biosphere.**
2. **Recognize that radiometric data indicate that Earth is at least 4 billion years old and that Earth has changed during that period.**
3. **Describe the internal structure of Earth (e.g., core, mantle, crust) and the structure of Earth's plates.**
4. **Understand the changes in Earth's past and the investigative methods used to determine geologic time, including:**
   - **rock sequences, relative dating, fossil correlation, and radiometric dating**

- **geologic time scales, historic changes in life forms, and the evidence for absolute ages (e.g., radiometric methods, tree rings, paleomagnetism).**

5. **Explain plate tectonic theory and understand the evidence that supports it.**

Energy in Earth's System

6. **Know that Earth's systems are driven by internal (i.e., radioactive decay and gravitational energy) and external (i.e., the sun) sources of energy.**
7. **Describe convection as the mechanism for moving heat energy from deep within Earth to the surface and discuss how this process results in plate tectonics, including:**
   - **geological manifestations (e.g., earthquakes, volcanoes, mountain building) that occur at plate boundaries**
   - **impact of plate motions on societies and the environment (e.g., earthquakes, volcanoes).**
8. **Describe the patterns and relationships in the circulation of air and water driven by the sun's radiant energy, including:**
   - **patterns in weather systems related to the transfer of energy**
   - **differences between climate and weather**
   - **global climate, global warming, and the greenhouse effect**
   - **El Niño, La Niña, and other climatic trends.**

Geochemical Cycles

9. **Know that Earth's system contains a fixed amount of natural resources that cycle among land, water, the atmosphere, and living things (e.g., carbon and nitrogen cycles, rock cycle, water cycle, ground water, aquifers).**
10. **Describe the composition and structure of Earth's materials, including:**
    - **the major rock types (i.e., sedimentary, igneous, metamorphic) and their formation**
    - **natural resources (e.g., minerals, petroleum) and their formation.**
11. **Explain how layers of the atmosphere (e.g., ozone, ionosphere) change naturally and artificially.**
12. **Explain how the availability of ground water through aquifers can fluctuate based on multiple factors (i.e., rate of use, rate of replenishment, surface changes, and changes in temperature).**

Strand III: Science and Society

Standard I: Understand how scientific discoveries, inventions, practices, and knowledge influence, and are influenced by, individuals and societies.

9-12 Benchmark I: Examine and analyze how scientific discoveries and their applications affect the world, and explain how societies influence scientific investigations and applications.

Science and Technology

1. **Know how science enables technology but also constrains it, and recognize the difference between real technology and science fiction (e.g., rockets vs. antigravity machines; nuclear reactors vs. perpetual-motion machines; medical X-rays vs. Star-Trek tricorders).**
2. **Understand how advances in technology enable further advances in science (e.g., microscopes and cellular structure; telescopes and understanding of the universe).**
3. **Evaluate the influences of technology on society (e.g., communications, petroleum, transportation, nuclear energy, computers, medicine, genetic engineering) including both desired and undesired effects, and including some historical examples (e.g., the wheel, the plow, the printing press, the lightning rod).**
4. **Understand the scientific foundations of common technologies (e.g., kitchen appliances, radio, television, aircraft, rockets, computers, medical X-rays, selective breeding, fertilizers and pesticides, agricultural equipment).**
5. **Understand that applications of genetics can meet human needs and can create new problems (e.g., agriculture, medicine, cloning).**

6. **Analyze the impact of digital technologies on the availability, creation, and dissemination of information.**
7. **Describe how human activities have affected ozone in the upper atmosphere and how it affects health and the environment.**
8. **Describe uses of radioactivity (e.g., nuclear power, nuclear medicine, radiometric dating).**

Science and Society

9. **Describe how scientific knowledge helps decision makers with local, national, and global challenges (e.g., Waste Isolation Pilot Project [WIPP], mining, drought, population growth, alternative energy, climate change).**
10. **Describe major historical changes in scientific perspectives (e.g., atomic theory, germs, cosmology, relativity, plate tectonics, evolution) and the experimental observations that triggered them.**
11. **Know that societal factors can promote or constrain scientific discovery (e.g., government funding, laws and regulations about human cloning and genetically modified organisms, gender and ethnic bias, AIDS research, alternative-energy research).**
12. **Explain how societies can change ecosystems and how these changes can be reversible or irreversible.**
13. **Describe how environmental, economic, and political interests impact resource management and use in New Mexico.**
14. **Describe New Mexico's role in nuclear science (e.g., Manhattan Project, WIPP, national laboratories).**

Science and Individuals

15. **Identify how science has produced knowledge that is relevant to individual health and material prosperity.**
16. **Understand that reasonable people may disagree about some issues that are of interest to both science and religion (e.g., the origin of life on Earth, the cause of the Big Bang, the future of Earth).**
17. **Identify important questions that science cannot answer (e.g., questions that are beyond today's science, decisions that science can only help to make, questions that are inherently outside of the realm of science).**
18. **Understand that scientists have characteristics in common with other individuals (e.g., employment and career needs, curiosity, desire to perform public service, greed, preconceptions and biases, temptation to be unethical, core values including honesty and openness).**
19. **Know that science plays a role in many different kinds of careers and activities (e.g., public service, volunteers, public office holders, researchers, teachers, doctors, nurses, technicians, farmers, ranchers).**