Montana K-12 Science Content Standards Framework

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Adopted by the Montana Board of Public Education
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Montana K-12 Science

Content Standards Framework

Table of Contents

Introduction

In 2005 the Montana Board of Public Education initiated the Standards Revision Project to assure Montana citizens that its public schools are providing **all** children of our great state with challenging academic expectations. The Montana Board of Public Education is charged with the responsibility of leading a process of standards revision that meets the following guiding principles.

Revised learning standards which are academic in focus, rigorous but attainable, readily understandable, and designed to measure the progress of students toward meeting them, will lead to the improvement of Montana's schools and a brighter future for our people.

Revised standards must clearly and consistently identify what students should know, understand and be able to do. Parents, educators, and the greater Montana community must be involved in the revision process. Revised standards will provide a framework to help guide local curriculum and instruction, encouraging school districts and teachers to place emphasis on critical areas of learning. In addition, standards should be measured and made known to the Montana public.

With the vital purpose of improving Montana's schools as our goal, the Montana Board of Public Education sets forth the following criteria to guide the Standards Revision:

1. Standards will be academic in nature and content specific.
2. Standards will be challenging and rigorous.
3. Standards will be clear, understandable and free of jargon.
4. Standards will be measurable.
5. Standards will address diversity specifically fulfilling the commitment to implementing MCA 20-1-501, Indian Education for All.

With the purpose of developing a successful and useful product, the Montana Board of Public Education sets forth the following process to guide the Montana Standards Revision:

1. Use the existing Montana Standards Framework - current accreditation program delivery and foundation standards, content and performance standards and benchmarks, and existing structure (4^{th}, 8^{th}, and upon graduation);
2. Use proven practices from Montana classrooms;
3. Consider international, national and other states' standards;
4. Consider entrance expectations for workplace and postsecondary education;
5. Consider achievement and other related data;
6. Consider other research e.g., Education Northwest, School Redesign Network, National Study of School Evaluation, etc.;
7. Consider comments from professional education associations;
8. Consider comments from tribal and school district educators;
9. Consider recommendations from the Montana Advisory Council for Indian Education; and
10. Involve the Montana public.

Pursuant to Article X Sect 1(2) of the Constitution of the state of Montana and statutes §20-1-501 and §20-9-309 2(c) MCA, the implementation of these standards must incorporate the distinct and unique cultural heritage of Montana American Indians.

Components of the Science Content Standards Framework

The Science Content Standards Framework is a set of agreements, rationales, and rules that provides the foundation for standards-based science education in Montana. This framework is the blueprint for further development of key components, such as Essential Learning Expectations, Performance Rubrics, and curriculum. The content standards framework contains:

- K-12 content standards;
- rationale for each content standard;
- benchmarks at the end of grade 4, end of grade 8, and upon graduation;
- performance descriptors at the levels of novice, nearing proficiency, proficient and advanced;
- a glossary; and
- works cited.

In order to use this framework effectively, it is essential to understand the distinctions between and intended purpose of its various components.

Content Standards: The six science content standards indicate what all students should know, understand, and be able to do in science. Their purpose is to guide the science curriculum and to communicate the breadth of the science to be taught to all students. A district's curriculum should be designed so that learning encompasses all six standards.

Rationales: Outlines the fundamental reasons for each of the content standards and provides the basis for the knowledge and skills included in the benchmarks.

Benchmarks: The benchmarks define expectations for students' scientific knowledge and skills along a developmental continuum. They define expectations for proficient students at the end of grade 4, end of grade 8, and upon graduation. Their purpose is to state clearly and specifically what the students should know and be able to do within each content standard. A district's curriculum should include the entire progression of knowledge contained in the benchmarks.

Performance Descriptors: Performance descriptors define how well students apply the knowledge and skills they have acquired. They gauge the level to which benchmarks have been attained in terms of range, frequency, facility, depth, creativity and quality. Achievement of curricular goals is assessed by the performance descriptors.

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Preface to Science Content Standards

Science is an inquiry process used to investigate natural phenomena, resulting in the formation of theories verified by directed observations. Inquiry challenges students to solve problems by observing and collecting data and constructing inferences from those data. In doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories (National Research Council, *National Science Education Standards* 214). Inquiry requires the use of scientific thinking skills to address open-ended problems through non-prescriptive procedures and allows students to construct their own knowledge of the specific concepts. This validates different ways of gathering, synthesizing and communicating knowledge. Scientific theories are challengeable and changeable. Data used to support or contradict them must be reproducible.

A goal of science education ". . . is to help students recognize the difference between personal opinion and knowledge gained through scientific investigation and debate" (*Science Framework for the 2005 National Assessment of Educational Progress* 8). "Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries" (National Research Council, *National Science Education Standards* 23).

Although science as a body of knowledge is ever changing, the processes of science are constant. In scientific inquiry, a problem is identified, pertinent data is gathered, hypotheses are formulated, experiments are performed, the results are interpreted, and conclusions are drawn. Science education strengthens students' investigative skills and fosters their understanding of the world. Students acquire and apply critical thinking and problem-solving skills necessary to participate as citizens in dynamic, global technological societies. Thinking skills, for example, observing, measuring, classifying, predicting, deducing, and inferring are given meaning by the context of the subject matter being studied (*Science Framework for the 2005 National Assessment of Educational Progress* 8).

The unifying concepts and processes of science provide connections between and among traditional scientific disciplines. The unifying concepts and processes woven into the Montana Standards for Science include: systems, order, and organization; evidence, models and explanation; constancy, change, and measurement; evolution and equilibrium; and form and function. These concepts and processes must be experienced in a developmentally appropriate manner during K-12 science education.

Science Content Standard 1

Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate the results and form reasonable conclusions of scientific investigations.

Rationale

Students must understand the process of science—how information is gathered, evaluated and communicated to others. Learning by inquiry mirrors the process of science itself. The knowledge and skills related to scientific inquiry enable students to understand how science works. Inquiry allows students to construct an understanding of scientific facts, principles, concepts and applications. In addition, scientific inquiry stimulates student interest, motivation and creativity.

Safety is a fundamental concern in all experimental science. Appropriate safety procedures must be applied when storing, using, and caring for materials.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
1.1 develop the abilities necessary to safely conduct scientific inquiry, including (a step-by-step sequence is not implied): (a) asking questions about objects, events, and organisms in the environment, (b) planning and conducting simple investigations	**1.1** identify a question, determine relevant variables and a control, formulate a testable hypothesis, plan and predict the outcome of an investigation, safely conduct scientific investigation, and compare and analyze data	**1.1** generate a question, identify dependent and independent variables, formulate testable, multiple hypotheses, plan an investigation, predict its outcome, safely conduct the scientific investigations, and collect and analyze data
1.2 select and use appropriate tools including technology to make measurements (including metric units) and represent results of basic scientific investigations	**1.2** select and use appropriate tools including technology to make measurements (in metric units), gather, process and analyze data from scientific investigations	**1.2** select and use appropriate tools including technology to make measurements (in metric units), gather, process and analyze data from scientific investigations using appropriate mathematical analysis, error analysis, and graphical representation

Science Content Standard 1

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
1.3 use data to describe and communicate the results of scientific investigations	**1.3** review, communicate and defend results of investigations, including considering alternative explanations	**1.3** review evidence, communicate and defend results, and recognize that the results of a scientific investigation are always open to revision by further investigations. (e.g., through graphical representation or charts)
1.4 use models that illustrate simple concepts and compare those models to the actual phenomenon	**1.4** create models to illustrate scientific concepts and use the model to predict change (e.g., computer simulation, stream table, graphic representation)	**1.4** analyze observations and explain with scientific understanding to develop a plausible model (e.g., atom, expanding universe)
1.5 identify a valid test in an investigation	**1.5** identify strengths and weakness in an investigation design	**1.5** identify strengths, weaknesses, and assess the validity of the experimental design of an investigation through analysis and evaluation
1.6 identify how observations of nature form an essential base of knowledge among the Montana American Indians	**1.6** compare how observations of nature form an essential base of knowledge among the Montana American Indians	**1.6** explain how observations of nature form an essential base of knowledge among the Montana American Indians

Science Content Standard 2

Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems.

Rationale

Matter exists in a variety of forms. All physical interactions involve changes in energy. Therefore, knowledge of matter and energy is essential to interpreting, explaining, predicting, and influencing change in our world.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
2.1 create mixtures and separate them based on different physical properties (e.g., salt and sand, iron filings and soil, oil and water)	**2.1** classify, describe, and manipulate the physical models of matter in terms of: elements, and compounds, pure substances and mixtures, atoms, and molecules	**2.1** describe the structure of atoms, including knowledge of (a) subatomic particles and their relative masses, charges, and locations within the atom, (b) the electrical and nuclear forces that hold the atom together, (c) fission and fusion, and (d) radioactive decay
2.2 examine, measure, describe, compare and classify objects in terms of common physical properties	**2.2** examine, describe, compare and classify objects and substances based on common physical properties and simple chemical properties	**2.2** explain how the particulate-level structure and properties of matter affect its macroscopic properties, including the effect of (a) valence electrons on the chemical properties of elements and the resulting periodic trends in these properties, (b) chemical bonding,(c) molecular geometry and intermolecular forces, (d) kinetic molecular theory on phases of matter, and (e) carbon-carbon atom bonding on biomolecules

Science Content Standard 2

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
2.3 identify the basic characteristics of light, heat, motion, magnetism, electricity and sound	**2.3** describe energy and compare and contrast the energy transformations and the characteristics of light, heat, motion, magnetism, electricity, sound and mechanical waves	**2.3** describe the major features associated with chemical reactions, including (a) giving examples of reactions important to industry and living organisms, (b) energy changes associated with chemical changes, (c) classes of chemical reactions, (d) rates of reactions, and (e) the role of catalysts
2.4 model and explain that matter exists as solids, liquids, and gases and can change from one form to another	**2.4** model and explain the states of matter are dependent upon the quantity of energy present in the system and describe what will change and what will remain unchanged at the particulate level when matter experiences an external force or energy change	**2.4** identify, measure, calculate, and analyze relationships associated with matter and energy transfer or transformations, and the associated conservation of mass
2.5 identify that the position of an object can be described by its location relative to another object and its motions described, and measured by external forces acting upon it	**2.5** describe and explain the motion of an object in terms of its position, direction, and speed as well as the forces acting upon it	**2.5** explain the interactions between motions and forces, including (a) the laws of motion and (b) an understanding of the gravitational and electromagnetic forces
2.6 identify, build, and describe mechanical systems and the forces acting within those systems	**2.6** identify, build, describe, measure, and analyze mechanical systems (e.g., simple and complex compound machines) and describe the forces acting within those systems	**2.6** explain how energy is stored, transferred, and transformed, including (a) the conservation of energy, (b) kinetic and potential energy and energy contained by a field, (c) heat energy and atomic and molecular motion, and (d) energy tends to change from concentrated to diffuse
2.7 observe, measure and manipulate forms of energy: sound, light, heat, electrical, magnetic	**2.7** give examples and describe how energy is transferred and conserved (e.g.; electric to light and heat [light bulb], chemical to mechanical [fuel to propulsion])	**2.7** describe how energy and matter interact, including (a) waves, (b) the electromagnetic spectrum, (c) quantization of energy, and (d) insulators and conductors

Science Content Standard 3

Students, through the inquiry process, demonstrate knowledge of characteristics, structures and function of living things, the process and diversity of life, and how living organisms interact with each other and their environment.

Rationale

Students gain a better understanding of the world around them if they study a variety of organisms, both microscopic and macroscopic. Through the study of similarities and differences of organisms, students learn the importance of classification and the diversity of living organisms. The understanding of diversity helps students understand biological evolution and life's natural processes (e.g., cycles, growth, and reproduction). Structure, function, body organization, growth and development, health and disease are important aspects to the study of life. The study of living systems provides students important information about how humans critically impact Earth's biomes.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
3.1 identify that plants and animals have structures and systems that serve different functions for growth, survival, and reproduction	**3.1** compare the structure and function of prokaryotic cells (bacteria) and eukaryotic cells (plant, animal, etc.) including the levels of organization of the structure and function, particularly with humans	**3.1** investigate and use appropriate technology to demonstrate that cells have common features including differences that determine function and that they are composed of common building blocks (e.g., proteins, carbohydrates, nucleic acids, lipids)
3.2 identify, measure, and describe basic requirements of energy and nutritional needs for an organism.	**3.2** explain how organisms and systems of organisms obtain and use energy resources to maintain stable conditions (e.g., food webs, photosynthesis, respiration)	**3.2** describe and explain the complex processes involved in energy use in cell maintenance, growth, repair and development
3.3 describe and use models that trace the life cycles of different plants and animals and discuss how they differ from species to species	**3.3** communicate the differences in the repro-ductive processes of a variety of plants and animals using the principles of genetic modeling (e.g., Punnett squares)	**3.3** model the structure of DNA and protein synthesis, discuss the molecular basis of heredity, and explain how it contributes to the diversity of life

Science Content Standard 3

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
3.4 explain cause and effect relationships between nonliving and living components within ecosystems; and explain individual response to the changes in the environment including identifying differences between inherited, instinctual, and learned behaviors	**3.4** investigate and explain the interdependent nature of populations and communities in the environment and describe how species in these populations adapt by evolving	**3.4** predict and model the interaction of biotic and abiotic factors that affect populations through natural selection, and explain how this contributes to the evolution of species over time
3.5 create and use a classification system to group a variety of plants and animals according to their similarities and differences	**3.5** create and use a basic classification scheme to identify plants and animals	**3.5** generate and apply biological classification schemes to infer and discuss the degree of divergence between ecosystems

Science Content Standard 4

Students, through the inquiry process, demonstrate knowledge of the composition, structures, processes and interactions of Earth's systems and other objects in space.

Rationale

By studying Earth, its composition, history and the processes that shape it, students gain a better understanding of the planet on which they live. Changes in lithosphere, atmosphere, and hydrosphere have profound effects on human existence. Knowledge of the Solar System and the universe helps students make predictions about Earth and informed decisions about the future.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
4.1 describe and give examples of Earth's changing features	**4.1** model and explain the internal structure of the Earth and describe the formation and composition of Earth's external features in terms of the rock cycle and plate tectonics and constructive and destructive forces	**4.1** understand the theory of plate tectonics and how it explains the inter-relationship between earthquakes, volcanoes, and sea floor spreading
4.2 describe and measure the physical properties of Earth's basic materials (including soil, rocks, water and gases) and the resources they provide	**4.2** differentiate between rock types and mineral types and classify both by how they are formed and the utilization by humans	**4.2** identify and classify rocks and minerals based on physical and chemical properties and the utilization by humans (e.g., natural resources, building materials)
4.3 investigate fossils and make inferences about life, the plants, animals, and the environment at that time	**4.3** use fossils to describe the geological timeline	**4.3** explain scientific theories about how fossils are used as evidence of changes over time
4.4 observe and describe the water cycle and the local weather and demonstrate how weather conditions are measured	**4.4** describe the water cycle, the composition and structure of the atmosphere, and the impact of oceans on large-scale weather patterns	**4.4** collect and analyze local and regional weather data to make inferences and predictions about weather patterns; explain factors influencing global weather and climate; and describe the impact on Earth of fluctuations in weather and climate (e.g., drought, surface and ground water, glacial instability)

Science Content Standard 4

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
4.5 identify seasons and explain the difference between weather and climate	**4.5** describe and model the motion and tilt of Earth in relation to the sun, and explain the concepts of day, night, seasons, year, and climatic changes	**4.5** explain the impact of terrestrial, solar, oceanic, and atmosphere conditions on global climatic patterns
4.6 identify objects (e.g., moon, stars, meteors) in the sky and their patterns of movement and explain that light and heat comes from a star called the sun	**4.6** describe the Earth, moon, planets and other objects in space in terms of size, force of gravity, structure, and movement in relation to the sun	**4.6** describe the origin, location, and evolution of stars and their planetary systems in respect to the solar system, the milky way, the local galactic group, and the universe
4.7 identify technology and methods used for space exploration (e.g., star parties, space shuttles, telescopes)	**4.7** identify scientific theories about the origin and evolution of the Earth and the solar system	**4.7** relate how evidence from advanced technology applied to scientific investigations (e.g., large telescopes and space-borne observatories), has dramatically impacted our understanding of the origin, size, and evolution of the universe

Science Content Standard 5

Students, through the inquiry process, understand how scientific knowledge and technological developments impact communities, cultures and societies.

Rationale

Our world and human activity is shaped in many ways by the advances in science. Science and technology are parallel in that science drives technological advances and these advances drive future scientific endeavors. Many different cultures contribute to science and technology. These advances affect different societies in different ways. It is vital that students understand the interrelationships of science, technology and human activity.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
5.1 describe and discuss examples of how people use science and technology	**5.1** describe the specific fields of science and technology as they relate to occupations within those fields	**5.1** predict how key factors (e.g., technology, competitiveness, and world events) affect the development and acceptance of scientific thought
5.2 describe a scientific or technological innovation that impacts communities, cultures, and societies	**5.2** apply scientific knowledge and process skills to understand issues and everyday events	**5.2** give examples of scientific innovation challenging commonly held perceptions
5.3 simulate scientific collaboration by sharing and communicating ideas to identify and describe problems	**5.3** simulate collaborative problem solving and give examples of how scientific knowledge and technology are shared with other scientists and the public	**5.3** evaluate the ongoing, collaborative scientific process by gathering and critiquing information
5.4 use scientific knowledge to make inferences and propose solutions for simple environmental problems	**5.4** use scientific knowledge to investigate problems and their proposed solutions and evaluate those solutions while considering environmental impacts	**5.4** analyze benefits, limitations, costs, consequences, and ethics involved in using scientific and technological innovations (e.g., biotechnology, environmental issues)
5.5 identify how the knowledge of science and technology influences the development of the Montana American Indian cultures	**5.5** describe how the knowledge of science and technology influences the development of the Montana American Indian cultures	**5.5** explain how the knowledge of science and technology applies to contemporary Montana American Indian communities (e.g., natural resources development, management and conservation)

Science Content Standard 6

Students understand historical developments in science and technology.

Rationale

Students need to understand that scientific knowledge was influenced greatly by societal influences. They also need to know that scientific and technological advances have influenced society. For instance, the development of the atom bomb and the discovery that microbes cause disease both had a major impact on society. Therefore, the use of history in school science programs is necessary to clarify different aspects of scientific discovery, to understand that scientific knowledge is publicly shared and to understand the role that science has played in the development of various cultures.

Benchmarks

A proficient student will:

End of Grade 4	End of Grade 8	Upon Graduation
6.1 give historical examples of scientific and technological contributions to communities, cultures and societies, including Montana American Indian examples	**6.1** give examples of scientific discoveries and describe the interrelationship between technological advances and scientific understanding, including Montana American Indian examples	**6.1** analyze and illustrate the historical impact of scientific and technological advances, including Montana American Indian examples
6.2 describe how scientific inquiry has produced much knowledge about the world and a variety of contributions toward understanding events and phenomenon within the universe	**6.2** identify major milestones in science that have impacted science, technology, and society	**6.2** trace developments that demonstrate scientific knowledge is subject to change as new evidence becomes available
6.3 describe science as a human endeavor and an ongoing process	**6.3** describe and explain science as a human endeavor and an ongoing process	**6.3** describe, explain, and analyze science as a human endeavor and an ongoing process

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Montana K-12 Science Performance Descriptors A Profile of Four Levels

The Science Performance Descriptors define how well students perform at four performance levels: advanced, proficient, nearing proficiency, and novice. These profiles describe students as they apply the knowledge and skills defined in the benchmarks for the End of Grade 4, End of Grade 8, and Upon Graduation.

Advanced	Proficient	Nearing Proficiency	Novice
A student at the advanced level demonstrates superior performance. He/she:	A student at the proficient level demonstrates solid academic performance. He/she:	A student at the nearing proficiency level demonstrates partial mastery of the prerequisite knowledge and skills fundamental for proficiency. He/she:	A student at the novice level is beginning to attain the prerequisite knowledge and skills that are fundamental for proficiency. He/she:

End of Grade 4			
Advanced	Proficient	Nearing Proficiency	Novice
safely completes a simple investigation by asking questions, using appropriate tools and with identified variables, identifies relationships and communicates results, and identifies that observation is a key inquiry process used by Montana American Indians	with direction, safely completes a simple investigation by asking questions with identified variables, uses appropriate tools, communicates results, and identifies that observation is a key inquiry process used by Montana American Indians	identifies and describes a simple investigation, and with step-by-step direction, given the appropriate tools, identifies and describes a simple safe investigation, and identifies that observation is a key inquiry process used by Montana American Indians	with direction, identifies and describes a safe, simple investigation with identified variables, and identifies that observation is a key inquiry process used by Montana American Indians
selects and accurately uses tools for measurement of solids, liquids, and gases, identifying properties of each state of matter, and describes and models characteristics of and changes within physical and mechanical systems	selects and uses tools for simple measurement of solids, liquids, and gases, identifying properties of each state of matter, and describes and models characteristics of and changes within basic physical and mechanical systems	with direction, effectively uses tools for simple measurement of solids, liquids, and gases, naming some properties of each state of matter, and names components of basic physical and mechanical systems	with direction, identifies and uses tools for simple measurement of solids, liquids, and gases; with direction, identifies basic components of basic physical and mechanical systems

End of Grade 4 (cont.)			
Advanced	Proficient	Nearing Proficiency	Novice
identifies multiple attributes of biotic (living) and abiotic (nonliving) objects, including: classification based on similarities and differences; describes and models structures, functions, and processes of biotic (living) and abiotic (nonliving) systems	identifies attributes of biotic (living) things and abiotic (nonliving) objects, including: classification based on similarities and differences, basic structure and function, processes of each system	with direction, identifies some of biotic (living) and abiotic (nonliving) objects; groups objects based on common attributes; provides basic descriptions of structure, function, and processes of a system	with direction, identifies basic attributes of biotic (living) and abiotic (nonliving) objects; groups objects based on common attributes
describes and explains the details of Earth's physical features and cycles	identifies and accurately illustrates Earth's features, locating several observable changes of those features	with direction, identifies some and describes Earth's features and recognizes simple, observable changes of those features	with direction, identifies basic Earth's features and identifies fundamental changes of those features
discusses interactions among technology, science, and society	identifies interactions among technology, science, and society	with direction, identifies some interactions among technology, science and society	with direction, identifies how basic scientific inquiry can blend current events and local issues
independently identifies scientific information in the news and discusses the possible impact on local problems	discusses scientific information related to current events and local problems	with direction, discusses how science plays a role in current events and local problems	with direction, identifies how science plays a role in current events and local problems
identifies the historical significance of scientists, discusses the impacts of their discoveries on humans today, and identifies influences of science and technology on the development of Montana American Indian cultures	identifies the historical significance of scientists, identifies the impacts of their discoveries on humans today, and identifies influences of science and technology on the development of Montana American Indian cultures	with direction, identifies some of the historical significance of scientists; identifies the impacts of their discoveries on humans today; and identifies influences of science and technology on the development of Montana American Indian cultures	with direction, identifies the basic historical significance of a prominent scientist; identifies the impact of his or her discoveries on humans today; and identifies influences of science and technology on the development of Montana American Indian cultures
identifies examples of Montana American Indian contributions to scientific and technological knowledge	identifies examples of Montana American Indian contributions to scientific and technological knowledge	with direction, identifies some examples of Montana American Indian contributions to scientific and technological knowledge	with direction, identifies an example of Montana American Indian contribution to scientific and technological knowledge

End of Grade 8			
Advanced	Proficient	Nearing Proficiency	Novice
generates testable questions, safely constructs a plan for a controlled investigation, makes logical inferences based on observations, accurately interprets data by identifying the strengths and weaknesses in an investigation design, communicates results, and communicates that observation is a key inquiry process used by Montana American Indians	identifies and communicates testable questions, safely plans and conducts experimental investigations, communicates results, and communicates that observation is a key inquiry process used by Montana American Indians	with step-by-step direction identifies and communicates testable questions, safely plans a controlled investigation, making simple inferences based on observations and interpretation of data, and communicates that observation is a key inquiry process used by Montana American Indians	identifies and describes a testable question, plans for a safely controlled investigation, makes simple observations, and communicates that observation is a key inquiry process used by Montana American Indians
uses physical, mental, theoretical, and mathematical models to investigate individually generated problems and/or questions about physical and chemical phenomena	given supporting detail, describes the physical world through the application of simple chemical reactions, chemical formulas, physical, theoretical and mathematical models	gives explanations describing the physical world; through the use of simple chemical reactions, chemical formulas and physical laws, and physical models	with direction describes the physical world; identifies simple chemical reactions, chemical formulas, and demonstrates a limited understanding of physical models
organizes, classifies, and describes interactions of the biotic (living) and abiotic (nonliving) parts of the biosphere as well as the natural history of interactions of life on Earth and uses these skills to solve related novel (to the student) problems	identifies and classifies biotic (living) things and abiotic (nonliving) objects through the application of common classification schemes; identifies the interdependence of life and the environment, and explains how characteristics of living things change because of the environment	describes interactions of the biotic (living) and abiotic (nonliving) parts of the biosphere; uses common classification schemes, lists examples of the interdependence of life and the environment	with direction, describes some basic interactions of the biotic (living) and abiotic (nonliving) parts of the biosphere; with direction provides basic descriptions of structure and function
describes, explains and models the processes that occur in the lithosphere, hydrosphere, and atmosphere of the Earth and the universe	describes and explains the structure and function of the Earth's lithosphere, hydrosphere, and atmosphere and the universe	describes the basic structure and function of the Earth's lithosphere, hydrosphere, and atmosphere and the universe	with direction, identifies and describes the basic structure and function of the Earth's lithosphere, hydrosphere, and atmosphere and the universe

End of Grade 8 (cont.)			
Advanced	Proficient	Nearing Proficiency	Novice
analyzes and communicates connections and interactions among technology, science, and society by applying scientific inquiry	describes connections and interactions among technology, science, and society by applying scientific inquiry	with direction, describes connections and interactions among technology, science, and society by applying scientific inquiry	with direction, identifies connections and interactions among technology, science, and society
makes informed decisions about scientific and social issues based on observations, data, analysis, and knowledge of the natural world, and effectively communicates those decisions to others	describes scientific information related to current events, and the impact on local problems	expresses how current events impact local problems and with prompting, can discuss scientific information that effects these problems	with direct instruction, can discuss basic scientific information in current events and how it impacts local problems
independently identifies and describes examples of how science and technology are the results of human activity throughout history, independently seeks new information that connects past to present, and describes influences of science and technology on Montana American Indian cultures	independently identifies and describes examples of how science and technology are the results of human activity throughout history, seeks new information that connects past to present, and describes influences of science and technology on Montana American Indian cultures	with direction, identifies and describes examples of how science and technology are the results of human activity throughout history; seeks new information that connects past to present; and describes influences of science and technology on Montana American Indian cultures	with direction, identifies and describes examples of how science and technology are the results of human activity throughout history; describes influences of science and technology on Montana American Indian cultures
describes and explains multiple examples of Montana American Indian contributions to scientific and technological knowledge	describes and explains multiple examples of Montana American Indian contributions to scientific and technological knowledge	with direction, describes examples of Montana American Indian contributions to scientific and technological knowledge	with direction, describes examples of Montana American Indian contributions to scientific and technological knowledge

Upon Graduation			
Advanced	Proficient	Nearing Proficiency	Novice
formulates testable questions, safely constructs a plan, makes logical inferences, interprets data by identifying the strengths and weaknesses, communicates results, presents another investigation that more accurately assesses the topic of study, and explains that observation is a key inquiry process used by Montana American Indians	generates testable questions, safely constructs a plan for a controlled investigation, makes logical inferences based on observations, accurately interprets data by identifying the strengths and weaknesses in an investigation design, communicates results, and describes and explains that observation is a key inquiry process used by Montana American Indians	with step-by-step direction, safely conducts and communicates the results from simple investigations, sometimes inferring real world applications and explains that observation is a key inquiry process used by Montana American Indians	identifies, describes, and safely conducts a simple investigation, identifies a variable and makes real world applications, and, with direction, explains that observation is a key inquiry process used by Montana American Indians
creates and uses physical, mental, theoretical, and mathematical models to investigate individually generated problems and/or questions about physical and chemical phenomena	uses physical, mental, theoretical, and mathematical models to investigate individually generated problems and/or questions about physical and chemical phenomena	identifies and constructs physical, mental, and mathematical models depicting the properties of matter in the physical world to investigate teacher-guided problems and/or questions about scientific phenomena	with direction, identifies and uses models depicting the properties of matter in the physical world
creates and uses physical, mental, theoretical, and mathematical models to investigate individually generated problems and/or questions about the biotic (living) and abiotic (nonliving) parts of the biosphere as well as the natural history of interactions of life on Earth and uses these skills to solve related novel (to the student) problems	organizes, classifies, and describes interactions of the biotic (living) and abiotic (nonliving) parts of the biosphere as well as the natural history of life on Earth and uses these skills to solve related novel (to the student) problems	uses models to investigate problems and/or questions about the biotic (living) and abiotic (nonliving) parts of the biosphere as well as the natural history of the interactions of life on earth	with direction, uses physical models to investigate problems and/or questions about the biotic (living) and abiotic (nonliving) parts of the biosphere and describes some factors which may cause the extinction of a species

Upon Graduation (cont.)			
Advanced	Proficient	Nearing Proficiency	Novice
creates and uses physical, mental, theoretical, and mathematical models to investigate individually generated problems and/or questions about the processes that occur in the lithosphere, hydrosphere, and atmosphere of the Earth and the universe	describes, explains and models the processes that occur in the lithosphere, hydrosphere, and atmosphere of the Earth and the universe	with direction, describes, explains, and models the processes that occur in the lithosphere, hydrosphere, and atmosphere of the Earth and the universe	with direction, describes and explains processes that occur in the lithosphere, hydrosphere, and atmosphere of the Earth and the universe
analyzes and evaluates connections and interactions among technology, science, and society by applying scientific inquiry	analyzes and communicates connections and interactions among technology, science, and society by applying scientific inquiry	identifies and describes connections and interactions among technology, science, and society by applying scientific inquiry	identifies connections and interactions among technology, science, and society by applying scientific inquiry
discriminately compares scientific and social issues based on observations, data, analysis, and knowledge of the natural world, and effectively communicates those decisions to others	makes informed decisions about scientific and social issues based on observations, data, analysis, and knowledge of the natural world and effectively communicates those decisions to others	using scientific inquiry, partially communicates interactions of science, technology, and society	identifies, but inconsistently communicates, interactions of science, technology, and their effect on society
identifies the positive and negative impacts of past, present, and future technological and scientific advances, gives possible solutions that may minimize the negative impacts on the global community, and describes and explains how science and technology apply to contemporary Montana American Indian communities	identifies the positive and negative impacts of past, present, and future technological and scientific advances, with direction, gives possible solutions that may minimize the negative impacts on the global community, and describes and explains how science and technology apply to contemporary Montana American Indian communities	identifies the positive and negative impacts of past, present, and future technological and scientific advances and describes how science and technology apply to contemporary Montana American Indian communities	with direction, identifies the positive and negative impacts of past, present, and future technological and scientific advances and, with direction, describes how science and technology apply to contemporary Montana American Indian communities

Upon Graduation (cont.)			
Advanced	Proficient	Nearing Proficiency	Novice
analyzes and explains Montana American Indian contributions to scientific and technological knowledge and analyzes and explains the historical impact of scientific and technological advances, including Montana American Indian examples	analyzes and explains Montana American Indian contributions to scientific and technological knowledge and analyzes and explains the historical impact of scientific and technological advances, including Montana American Indian examples	explains Montana American Indian contributions to scientific and technological knowledge and explains the historical impact of scientific and technological advances, including Montana American Indian examples	with direction, explains Montana American Indian contributions to scientific and technological knowledge and with direction describes the historical impact of scientific and technological advances, including Montana American Indian examples

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Denise Juneau, State Superintendent
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Montana K-12 Science Content Standards Framework Glossary

The glossary identifies and describes key terms within the content standards, benchmarks, and performance descriptors. The purpose of the glossary is to help educators better understand and implement the mathematics content standards, benchmarks and performance descriptors. **It is not intended to be a study guide for students and is not a comprehensive list of all science terms.**

Attribute - An inherent characteristic.

Classification - Systematic arrangement of objects or organisms into groups or categories according to established criteria.

Control – A group of test subjects left untreated or unexposed to the independent variable and then compared with treated subjects in order to validate the test results; the standard for comparing experimental effects. Not all experiments have a control, though all have controlled variables (Cothorn, Giese, and Rezba 17).

Controlled Variable - A variable that is not changed and is kept the same for all tests; also referred to as a constant (Cothorn, Giese, and Rezba 17).

Data – Qualitative or quantitative values collected through observation or experimentation from which conclusions may be drawn.

Dependent Variable – The observed or measured variable in an experiment or study whose changes are determined by the presence or degree of one or more independent variables; also referred to as the responding variable.

Error Analysis – The process used to evaluate the total error throughout an experiment and indicate the accuracy of experimental results. This can be due to bias error, precision error, as well as others.

Evidence – Data and documentation that may either support or help refute inferences or conclusions.

Evolution – A process of change that explains why what is seen today is different from what existed in the past; it includes changes in the galaxies, stars, solar system, Earth and life on earth. Biological evolution is any genetic and resulting phenotypic change in groups of organisms from generation to generation.

Experiment – The act of conducting a controlled test or investigation.

Fossil – Any recognizable structure originating from an organism, or any impression from such a structure, that has been preserved over geological time.

Geologic Timeline - a chronologic schema used by geologists and other earth scientists to describe the timing and relationships between events that have occurred during the history of Earth.

Hypothesis - A tentative explanation of a phenomenon, event, or the nature of an object based on prior experience, scientific background knowledge, preliminary observations, and logic. A hypothesis is testable (Fundamentals of Inquiry).

Independent Variable – A factor or condition that changes naturally or is intentionally manipulated by the investigator to observe the effect; also referred to as the manipulated variable.

Inquiry – A search for knowledge; a systematic process of teaching and learning where the learner:

- engages in scientifically oriented questions;
- gives priority to evidence in responding to questions;
- formulates explanations from evidence;
- connects explanations to scientific knowledge; and
- communicates and justifies explanations.

(National Research Council 25-29).

Investigate - To observe or study by using a systematic inquiry approach.

Law - Summarizing statement of observed experimental facts that has been tested many times and is generally accepted as true.

Model - A description, analogy or a representation of something that helps us understand it better (e.g., a physical model, a conceptual model, a mathematical model).

Natural Phenomenon - An occurrence, circumstance, or fact that exists in or formed by nature and is perceptible by the senses.

Observation - To gather information and direct evidence about an object, event or phenomenon by using the senses and/or appropriate tools.

Planet - A celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighborhood around its orbit (International Astronomical Union).

Plate Tectonics - Movements of the Earth's crustal plates, which result in changes in the position, size, and shape of continents and oceans (NASA Jet Propulsion Laboratory).

Prediction – A forecast of the outcome of a specific future event based on a pattern of evidence or a hypothesis (explanation). A predication based on a hypothesis can be used in planning a test of that hypothesis (Fundamentals of Inquiry).

Science - Systematic knowledge of the physical or material world gained through observation and experimentation.

Solar System - A system of planets, moons, asteroids, comets, dust, gas, and any other objects that orbit a star, tied to it by the star's gravitational force (NASA Space Place).

System - An organized group of related objects or components that form a whole.

Technology – 1. Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities; 2. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants (Massachusetts Science and Technology/Engineering).

Testable – A statement, question, or hypothesis that can be investigated through experimentation and/or observation.

Theory - Systematically organized knowledge applicable in a relatively wide variety of circumstances; especially, a system of assumptions, accepted principles and rules of procedure devised to analyze, predict or otherwise explain the nature or behavior of a specified set of phenomena ("Science Glossary").

Valid Test – Experimental design that consist of a change in one variable and a control group.

Variable - An attribute of a physical or an abstract system which may change its value while it is under observation.

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