



ADMINISTRATIVE RULES OF MONTANA

10.58.522 SCIENCE

- (1) The science program ensures that successful candidates follow the subject major and/or minor program of study or the broadfield major program of study. Subject major and/or minor teaching endorsement programs are limited to biology, earth science, chemistry, and physics. The physical science endorsement is a balanced combination of physics and chemistry. The broadfield major includes a concentration in one of the endorsable disciplines, coupled with balanced study in three other endorsable science disciplines. Science disciplines selected adhere to a scope and sequence which ensures a thorough grounding in the basic concepts, skills, and dispositions associated with Montana and national K-12 content standards.
- (2) The science endorsement requires that successful candidates:
 - (a) demonstrate a thorough understanding of the nature of science and essential science engineering practices, including:
 - (i) recent significant changes in the field, as reflected by Montana Science Content Standards, the science framework and their impact on the content knowledge necessary for teaching K-12 students;
 - (ii) understanding and articulating the knowledge and practices of contemporary science and engineering;
 - (iii) competency in basic mathematics, statistics, and current and emerging technological applications to science teaching;
 - (iv) preparation and experience in environmental science, including American Indians and tribes in Montana and their traditional relationships to the environment; and
 - (v) methods to engage in active inquiry lessons where students ask questions, develop and use models, plan and carry out investigations, analyze and interpret data using applicable science-specific technology, mathematics, and computational thinking, in order to construct explanations and solutions and communicate concepts by engaging in argument from evidence;
 - (b) demonstrate knowledge and skills in obtaining, evaluating, and communicating information using multiple sources in order to communicate claims, methods, and designs to others;
 - (c) use a variety of strategies that demonstrate the candidates' knowledge of the appropriate teaching and learning activities, including laboratory or field settings and applicable instruments and technology, or both;
 - (d) demonstrate safe laboratory management skills;

- (e) practice ethical treatment of living organisms in the classroom; and
 - (f) interrelate and interpret important concepts, ideas, and applications in their field of endorsement and supporting disciplines.
- (3) The candidate for an endorsement in earth science demonstrates the following core competencies:
- (a) conceptual understanding in the unifying concepts and processes of systems order and organization, evidence models and explanation, change, constancy, measurement, evolution and equilibrium, form and function;
 - (b) systematic and quantitative study of the fundamental topics in earth science interrelated and illustrated with descriptive and historical perspectives, as well as the applications of earth science in society;
 - (c) conceptual understanding of astronomy, geology, paleontology, meteorology, and oceanography, and their relations with each other;
 - (d) conceptual understanding of biology, chemistry, or physics, emphasizing the interrelationships among the sciences and their relations to earth science;
 - (e) conceptual understanding of mathematics, including a working knowledge of trigonometry and statistics;
 - (f) conceptual understanding of ethical and human implications of such contemporary issues as the impact of technologies on earth systems; and
 - (g) ability to design, develop, and evaluate field, demonstration, and laboratory instructional activities, and use special skills and techniques with equipment, technologies, and facilities which support and enhance curricula and instruction in earth science and especially techniques and strategies for using the local environment as a teaching/learning laboratory.
- (4) The candidate for an endorsement in biology demonstrates the following core competencies:
- (a) conceptual understanding of the life processes in living systems including organization of matter and energy;
 - (b) conceptual understanding of the similarities and differences among animals, plants, fungi, microorganisms, and viruses;
 - (c) conceptual understanding of living organisms, ethical laboratory and field studies promoting scientific inquiry, applications of biology in social and historical perspectives;
 - (d) conceptual understanding of the principles and practices of biological classification and the theory and principles of biological evolution;
 - (e) understanding of the ecological systems including the interrelationships and dependencies of organisms with each other and their environments;
 - (f) conceptual understanding of population dynamics and the impact of population on its environment;
 - (g) understanding of general concepts of genetics and heredity;
 - (h) conceptual understanding of organizations and functions of cells and multi-cellular systems;

- (i) understanding of the regulation of biological systems including homeostatic mechanisms;
 - (j) conceptual understanding of the fundamental processes of modeling and investigating in the biological sciences;
 - (k) understanding of the applications of biology in environmental quality and in personal and community health;
 - (l) conceptual understanding of bioenergetics including major biochemical pathways;
 - (m) understanding of biochemical interactions of organisms and their environments;
 - (n) conceptual understanding of molecular genetics and heredity and mechanisms of genetic modification;
 - (o) understanding of molecular basis for evolutionary theory and classification;
 - (p) conceptual understanding of the causes, characteristics, and avoidance of viral, bacterial, and parasitic diseases;
 - (q) understanding of the issues related to living systems such as genetic modification, uses of biotechnology, cloning, and pollution from farming; and
 - (r) conceptual understanding of applications of biology and biotechnology in society, business, industry, and health fields.
- (5) The candidate for an endorsement in chemistry demonstrates the following core competencies:
- (a) conceptual understanding in the unifying concepts and processes of systems order and organization, evidence models and explanation, change constancy, measurement, evolution and equilibrium, form and function;
 - (b) understanding of exploration and inquiry as tools in investigating all aspects of the natural environment and demonstrates knowledge of application and instruction using these methods when instructing students;
 - (c) conceptual understanding of the fundamental structures of atoms and molecules;
 - (d) understanding of the basic principles of ionic, covalent, and metallic bonding;
 - (e) conceptual understanding of the physical and chemical properties and classification of elements including periodicity;
 - (f) understanding of chemical kinetics and thermodynamics;
 - (g) conceptual understanding of the principles of electrochemistry;
 - (h) understanding of the Mole concept, stoichiometry, and laws of composition;
 - (i) conceptual understanding of solutions, colloids, and colligative properties;
 - (j) understanding of transition elements and coordination compounds;
 - (k) conceptual understanding of acids and bases, oxidation-reduction chemistry, and solutions;
 - (l) understanding of fundamental biochemistry;
 - (m) conceptual understanding of the applications of chemistry in personal and community health and environmental quality;

- (n) understanding of the molecular orbital theory, aromaticity, metallic and ionic structures, and correlation to properties of matter;
 - (o) conceptual understanding of the advanced concepts of chemical kinetics, and thermodynamics;
 - (p) understanding of Lewis structures and molecular geometry;
 - (q) conceptual understanding of major biological compounds and natural products;
 - (r) understanding of solvent system concepts;
 - (s) conceptual understanding of chemical reactivity and molecular structure including electronic and steric effects; and
 - (t) understanding of organic chemistry including syntheses, reactions, mechanisms, and aromaticity.
- (6) The candidate for an endorsement in physics demonstrates the following core competencies, including:
- (a) conceptual understanding of energy, work, and power;
 - (b) understanding of motion, major forces, and momentum;
 - (c) conceptual understanding of Newtonian physics with engineering applications;
 - (d) understanding of conservation, mass, momentum, energy, and charge;
 - (e) conceptual understanding of the physical properties of matter;
 - (f) understanding of kinetic-molecular motion and atomic models;
 - (g) conceptual understanding of radioactivity, nuclear reactors, fission, and fusion;
 - (h) understanding of wave theory, sound, light, the electromagnetic spectrum and optics;
 - (i) conceptual understanding of electricity and magnetism;
 - (j) understanding of the fundamental processes of investigating in physics;
 - (k) conceptual understanding of the applications of physics in environmental quality and to personal and community health;
 - (l) understanding of thermodynamics and energy-matter relationships;
 - (m) conceptual understanding of nuclear physics including matter-energy duality and reactivity;
 - (n) understanding of angular rotation and momentum, centripetal forces, and vector analysis;
 - (o) conceptual understanding of quantum mechanics, space-time relationships, and special relativity;
 - (p) understanding of models of nuclear and subatomic structures and behavior;
 - (q) conceptual understanding of light behavior, including wave-particle duality and models;
 - (r) understanding of electrical phenomena including electric fields, vector analysis, energy, potential, capacitance, and inductance;

- (s) conceptual understanding of issues related to physics such as disposal of nuclear waste, light pollution, shielding communication systems, and weapons development;
 - (t) understanding of historical development and cosmological perspectives in physics including contributions of significant figures and underrepresented groups, and evolution of theories in physics; and
 - (u) conceptual understanding of the applications of physics and engineering in society, business, industry, and health fields.
- (7) The candidate for an endorsement in broadfield science demonstrates the following core competencies:
- (a) conceptual understanding in the unifying concepts and processes of systems order and organization, evidence models and explanation, change constancy, measurement, evolution and equilibrium, form and function;
 - (b) ability to collect and interpret empirical data using applicable science-specific technology to develop science and engineering practices, understand the cross-cutting concepts and processes, relationships, and natural patterns;
 - (c) interdisciplinary study of the fundamental topics in biology, chemistry, physics, and earth science including descriptive and historical perspectives, as well as the applications of these sciences in society;
 - (d) study and experiences emphasizing interrelationships among all the sciences, as well as cross-cutting concepts of the sciences with other areas of study such as mathematics, technology, and engineering;
 - (e) understanding of mathematics, including a working knowledge of calculus and statistics;
 - (f) conceptual understanding of the relationships among science, science technologies, and the study of environmental education;
 - (g) designing, developing, and evaluating field experiences, demonstrations, and laboratory instructional activities, and in using special skills and techniques with equipment, technologies, facilities, and specimens which support and enhance curricula and instruction in all sciences including laboratory and field studies that promote the science and engineering practices, investigation and inquiry, and the use of experimental methods;
 - (h) conceptual understanding of earth sciences including content in astronomy, geology, paleontology, meteorology and oceanography, and their relationships with each other;
 - (i) conceptual understanding of biology including content in zoology, botany, physiology, genetics, ecology, microbiology, cell biology/biochemistry, and evolution, and their relationships with each other;
 - (j) conceptual understanding of chemistry including content in organic, inorganic, analytical, and biochemistry and their relationships with each other;
 - (k) conceptual understanding of physics including content in classical mechanics, electricity and magnetism, heat and thermodynamics, waves, optics, atomic and nuclear physics, radiation and radioactivity, relativity, quantum mechanics, and other fields of modern physics and their relationships with each other; and

- (l) facilitating classroom discourse through questioning, reflecting on, and critically analyzing ideas, leading students toward a deeper understanding of the inquiry process itself, and, especially, using questions to define problems and potential solutions.

Authorizing statute(s): 20-2-114, MCA

Implementing statute(s): 20-1-501, 20-2-121, MCA

History: NEW, 1979 MAR p. 492, Eff. 5/25/79; AMD, 1984 MAR p. 831, Eff. 5/18/84; AMD, 1989 MAR p. 397, Eff. 3/31/89; AMD, 2000 MAR p. 2406, Eff. 9/8/00; AMD, 2007 MAR p. 190, Eff. 2/9/07; AMD, 2014 MAR p. 2936, Eff. 7/1/15; AMD, 2023 MAR p. 86, Eff. 7/1/23.