Content and Performance Standards for Physics

(10) = areas covered in the 10th grade MontCas

Course Content Identification Numbers:

The first symbol represents the grade level, the second symbol is the number of the state standard being addressed, the third number is the state benchmark being addressed and the decimal number is for the course content that addresses that specific standard and benchmark.

Example: P 23.1: P=Physics, 2= standard 2, 3=benchmark 3, 1= the first course content skill under the benchmark

The Essential Vocabulary is based on OPI's recommended vocabulary though ACE has often expanded the list of terms. The vocabulary words in bold, are OPI suggested vocabulary and may well be used in MontCAS testing.

ACE Course Abilities for Physics to be applied to Content Standards:

Develop abilities in science.

A. Higher thinking (analyze, evaluate, classify, predict, decide, relate, interpret).
B. Communications (present, demonstrate).
C. Goal setting/attainment (brainstorm, envision, research, plan, organize).
D. The planning process (plan, draft, analyze, and revise when producing products).
E. Be able to use SI units appropriately.

Apply science knowledge and skills to a variety of purposes.

A. Use the scientific method to solve problems and conduct experiments.
B. Conduct research.
C. Use scientific equipment appropriately and safely.
D. Apply knowledge of the relationship between humans, the environment and the earth's resources to improve the environment.
E. Possess technical skills:
   - read/write/present i.e.: instructions, table, chart, reports (progress, research, lab), proposal, letters (complaint, request, response), manual, checklist, pamphlet, technical research, bid, technical analysis, summary
   - technology i.e.: word processing, spreadsheet, database, desktop publishing, Internet, search tools, current technology

Course Content For Physics

CONTENT STANDARD 1. Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

P11.0 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 the data.

.1 Identify the various applications of scientific investigations (explore new phenomena, check on previous results and compare hypotheses) **(10)**
.2 Identify testable questions **(10)**
.3 Identify, from a set of questions, which question can be analyzed using a given set of sample data **(10)**
.4 Distinguish the independent and dependent variables by examining a scientific experiment/investigation **(10)**
.5 Write a testable question **(10)**
.6 Generate a valid hypothesis **(10)**
.7 Discriminate between a testable question and a hypothesis **(10)**
.8 Compare and contrast a list of hypotheses to determine if they are testable
.9 Formulate a single or multiple hypotheses on any given experiment/investigation **(10)**
.11 Use the independent and dependent variable to determine the materials, tools and techniques needed for an investigation **(10)**
.12 Formulate a sequential plan for an investigation **(10)**
.13 Identify and apply appropriate safety practices for an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1 - .5: testable question, independent variable, Science, Scientific Method
.6 - .9: dependent variable, **hypothesis, experiment, investigation**

Course Content For Physics (cont.)

P12.0 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.

.1 Design data tables/setup and show an organizational strategy **(10)**
.2 Gather data (qualitative/quantitative) using appropriate measurements and methods **(10)**
.3 Apply the metric system by appropriate use of units and conversion factors **(10)**
.4 Apply appropriate mathematical analysis **(10)**
.5 Demonstrate graphing design (placement of dependent and independent variables/scaling/units/keys/titles/labels/graph types) **(10)**
.6 Identify possible sources of error **(10)**
.7 Identify and interpret trends in data using graphical analysis **(10)**
.8 Distinguish between precision and accuracy in measurement

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1 - .3: qualitative, quantitative, error analysis
.4 - .8: experimental error, precision, accuracy

P13.0 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 Identify techniques used to review evidence (summary, graphical organizers, models) **(10)**
.2 Identify relationship between data trends and scientific concepts **(10)**
.3 Determine appropriate communication techniques to communicate and defend results **(10)**
.4 Communicate interpretations and conclusions using scientific concepts, mathematical relationships and technology **(10)**
.5 Justify and defend conclusions based on evidence **(10)**
.6 Explain why conclusions based on evidence are open to revision upon further investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

evidence, conclusion

P14.0 Analyze observations and explain with scientific understanding to develop a plausible model (e.g., atom, expandinguniverse).

.1 Identify various types of models (physical, mental, graphical, and mathematical) that can be used to illustrate scientific concepts **(10)**
.2 Explain why models are used to express scientific concepts **(10)**
.3 Use models to investigate and represent scientific concepts **(10)**
.4 Generate a model based on evidence gathered in an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)*** **model**

Course Content For Physics (cont.)

P15.0 Identify strengths, weaknesses, and assess the validity of the experimental design of an investigation through analysis and evaluation.

.1 Identify and assess the characteristics of a valid investigation **(10)**
.2 Identify experimental error and communicate suggestions for modified or redesigned experiment **(10)**
.3 Compare and contrast the validity of various experiments designed to measure the same outcome **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***
valid, experimental design

P16.0 Explain how observations of nature form an essential base of knowledge among the Montana American Indians(go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Explain how observations of nature form and essential base of knowledge **(10)**
.2 Describe how Montana American Indians use observation to develop cultural knowledge and practices through examples **(10)**

CONTENT STANDARD 2—Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems.

P21.0 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.

.1 Compare and contrast subatomic particles in relation to their relative masses, charges and location **(10)**
.2 Compare and contrast the number of subatomic particles in different elements and their isotopes **(10)**
.3 Recognize there is an electrical force of attraction/repulsion **(10)**
.4 Recognize the forces that keep the nucleus intact
.5 Explain radioactive decay and provide examples **(10)**
.6 Explain nuclear fission and fusion and provide examples

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***
.1 - .2: electron, proton, neutron, element, isotope, atomic mass, atomic number
.3 - .4: electrical force, nuclear force
.5 - .6: radioactive decay, fission, fusion

Course Content For Physics (cont.)

P22.0 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.

.1 Compare and contrast ionic, covalent and hydrogen bonds **(10)**
.2 Describe the significance of electrons in interactions between atoms and why they sometimes form bonds
.3 Explain how the chemical bonding of a molecule affects its macroscopic (physical) properties
.4 Explain how the molecular geometry of a molecule (e.g. water) affects polarity and cohesive/adhesive properties **(10)**
.5 Describe the physical properties of each state of matter: solid, liquid, gas **(10)**
.6 Describe, using the kinetic molecular theory, the behavior of particles in each state of matter: solid, liquid, and gas

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1-.3: valence electrons, ions, chemical bond, ionic bonds, covalent bonds, hydrogen bonds
.4: polarity, cohesion, adhesion, **molecular geometry**

P23.0 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.

This benchmark is covered in Chemistry

P24.0 Identify, measure, calculate, and analyze relationships associated with matter and energy transfer or transformations, and the associated conservation of mass.

.1 Describe the law of conservation of mass **(10)**
.2 Measure and/or calculate energy transfer for a sample set of data or experiment
.3 Analyze the relationship between energy transfer and physical properties of matter
.4 Explain the unique circumstances allowing mass to transform into energy, or energy into mass

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

Law of Conservation of Mass

Course Content For Physics (cont.)

P25.0 Explain the interactions between motions and forces, including (a) the laws of motion and (b) an understanding of the gravitational and electromagnetic forces.

.1 Explain, given F = ma, the relationship between force and acceleration in uniform motion **(10)**
.2 Solve simple kinematics problems using the kinematics equations for uniform acceleration: $v_{avg}=d/t$, $a=\Delta v/t$, and $d=1/2\ at^2$ **(10)**
.3 Distinguish between a scalar quantity and a vector quantity.
.4 List different types of forces **(10)**
.5 Describe how change in velocity and /or change in direction affect acceleration
.6 Describe the role of friction in motion **(10)**
.7 Describe situations that illustrate Newton's three laws of motion **(10)**
.8 Explain the relationship between mass and distance in relation to gravitational force **(10)**
.9 Describe the relationship between magnetism and electricity and the resulting electromagnetic force
.11 Describe the Law of Conservation of momentum
.12 Relate horizontal and vertical motion to projectile motion and trajectory

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1 - .4: scalar quantity, vector quantity, force, mass, acceleration, velocity, kinematics
.5 - .12: **inertia, gravitational force, electromagnetic force**, friction, momentum, Law of Conservation of Momentum, projectile motion, trajectory

P26.0 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.

.1 Describe the differences between kinetic energy and potential energy **(10)**
.2 Explain the relationship between kinetic energy and potential energy in a system **(10)**
.3 Discuss the conservation of energy **(10)**
.4 Recognize heat as a form of energy transfer **(10)**
.5 Explain the relationship between temperature, heat and thermal energy **(10)**
.6 Define the kinetic molecular theory and its relationship to heat (thermal energy transfer).
.7 Relate how energy tends to change from concentrated to diffuse states.

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1 - .3: energy, potential energy, kinetic energy, **Law of Conservation of Energy**
.4 - .7: joules, calories, temperature, heat, energy transfer

Course Content For Physics (cont.)

P27.0 Describe how energy and matter interact, including (a) waves, (b) the electromagnetic spectrum, (c) quantization of energy, and (d) insulators and conductors.

.1 Identify and illustrate different types of waves **(10)**
.2 Compare and contrast the similarities and differences between longitudinal and transverse mechanical waves **(10)**
.3 Explain how waves interact with media.
.4 Compare the various electromagnetic waves (gamma rays, x-rays, ultraviolet, visible light, infrared, microwave, and radio waves) in terms of energy and wavelength **(10)**
.5 Identify practical uses of various electromagnetic waves **(10)**
.6 Compare the visible light colors in terms of energy and wavelength
.7 Recognize that atoms and molecules can gain or lose energy only in particular discrete amounts.
.8 Recognize that every substance emits and absorbs certain wavelengths
.9 Explain how electromagnetic waves are superposed, bent, reflected, refracted, and absorbed.
.11 Describe the Doppler Effect in relation to electromagnetic waves and mechanical waves
.12 Describe the difference between an electrical conductor and an electrical insulator **(10)**
.13 Describe the difference between a heat conductor and a heat insulator **(10)**
.14 Explain how electricity is involved in the transfer of energy **(10)**
.15 Explain the flow of electrons in relation to parallel circuits and series circuits.
.16 Describe the effects different electrical component (i.e., resistors, capacitors, transformers) have on the flow of electrons through electrical circuits.

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)***

.1 - .3: **amplitude, wavelength, frequency, period**, longitudinal wave, transverse mechanical wave
.4 - .11: **electromagnetic spectrum, photon, reflection, refraction**, Doppler effect
.12 - .16: **current, resistance, voltage, power, conductor, insulator,** series circuits, parallel circuits, resistor transformer, capacitors

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.

All benchmarks under Standard 3 are addressed in Biology Course Content (B)

Course Content For Physics (cont.)

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.

All benchmarks under Standard 4 are addressed in the High School Earth Science Course Content (E)

CONTENT STANDARD 5—Students, through the inquiry process, understand how scientific knowledge and technological developments impact communities, cultures and societies.

P51.0 Predict how key factors (e.g., technology, competitiveness, and world events) affect the development and acceptance of scientific thought.

.1 Identify an example of scientific thought that has been or is affected by key factors such as technology, competitiveness (industrial, political, religious, etc.), world events, etc **(10)**
.2 Analyze how the development and/or acceptance of this example was influenced by various factors **(10)**
.3 Justify the analysis using cited peer-reviewed sources **(10)**
.4 Predict and discuss how key factors could impact the development and acceptance of scientific thought **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Physics)*** **peer-review**

P52.0 Give examples of scientific innovation challenging commonly held perceptions.

.1 Identify and discuss examples of commonly held perceptions or ideas being challenged by science (i.e. heliocentrism, flat earth, spontaneous generation) **(10)**

P53.0 Evaluate the ongoing, collaborative scientific process by gathering and critiquing information.

.1 Identify and discuss the practices employed by scientists to collaborate, share, and critique scientific information **(10)**
.2 Summarize the peer review process scientists use to critique and publish scientific research**(10)**
.3 Compare and contrast the formal and informal methods by which scientists communicate with each other and the public**(10)**

P54.0 Analyze benefits, limitations, costs, consequences, and ethics involved in using scientific and technological innovations (e.g., biotechnology, environmental issues).

.1 Identify various scientific and technological innovations **(10)**
.2 Compare and contrast the benefits and limitations of the various innovations **(10)**
.3 Analyze the cost and consequences of the innovations **(10)**
.4 Examine the ethical issues involved with the innovations **(10)**

Course Content For Physics (cont.)

P55.0 Explain how the knowledge of science and technology applies to contemporary Montana American Indian communities (e.g., natural resources development, management and conservation) (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify current practices by Montana American Indian tribes that are influenced by knowledge of science and technology **(10)**
.2 Explain how tribal sovereignty affects the use of science and technology within Montana American Indian communities **(10)**

CONTENT STANDARD 6—Students understand historical developments in science and technology.

P61.0 Analyze and illustrate the historical impact of scientific and technological advances, including Montana American Indian examples (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify important historical events in science and technology **(10)**
.2 Analyze the positive and negative impacts of past, present, and future science and technological advances **(10)**

P62.0 Trace developments that demonstrate scientific knowledge is subject to change as new evidence becomes available.

.1 Identify examples of scientific knowledge that have changed over time **(10)**
.2 Discuss the developments that contributed to the progression of the scientific knowledge **(10)**
.3 Analyze the impact of each development on the scientific knowledge **(10)**
.4 Summarize the process of the advancement of scientific knowledge **(10)**

P63.0 Describe, explain, and analyze science as a human endeavor and an ongoing process.

.1 Discuss the purpose of science **(10)**
.2 Summarize the parameters that guide the process of science **(10)**
.3 Examine the role of human reasoning in the process of science **(10)**
.4 Analyze how human interpretation of evidence affects the process of science **(10)**
.5 Describe how science is an ongoing process **(10)**

Content and Performance Standards for Biology

(10) = areas covered in the 10th grade MontCas

Course Content Identification Numbers:

The first symbol represents the grade level, the second symbol is the number of the state standard being addressed, the third number is the state benchmark being addressed and the decimal number is for the course content that addresses that specific standard and benchmark.

Example: B 23.1: B=Biology, 2= standard 2, 3=benchmark 3, 1= the first course content skill under the benchmark

The Essential Vocabulary is based on OPI's recommended vocabulary though ACE has often expanded the list of terms. The vocabulary words in bold, are OPI suggested vocabulary and may well be used in MontCAS testing.

ACE Course Abilities for Biology to be applied to Content Standards:

Develop abilities in science.

A. Higher thinking (analyze, evaluate, classify, predict, decide, relate, interpret).
B. Communications (present, demonstrate).
C. Goal setting/attainment (brainstorm, envision, research, plan, organize).
D. The planning process (plan, draft, analyze, and revise when producing products).
E. Be able to use SI units appropriately.

Apply science knowledge and skills to a variety of purposes.

A. Use the scientific method to solve problems and conduct experiments.
B. Conduct research.
C. Use scientific equipment appropriately and safely.
D. Apply knowledge of the relationship between humans, the environment and the earth's resources to improve the environment.
E. Possess technical skills:
   - read/write/present i.e.: instructions, table, chart, reports (progress, research, lab), proposal, letters (complaint, request, response), manual, checklist, pamphlet, technical research, bid, technical analysis, summary
   - technology i.e.: word processing, spreadsheet, database, desktop publishing, Internet, search tools, current technology

Course Content for Biology

CONTENT STANDARD 1. Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

B11.0 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 the data.

.1 Identify the various applications of scientific investigations (explore new phenomena, check on previous results, develop and test hypothesis, and compare hypotheses) **(10)**
.2 Identify testable questions **(10)**
.3 Identify, from a set of questions, which question can be analyzed using a given set of sample data **(10)**
.4 Distinguish the independent and dependent variables by examining a scientific experiment/investigation **(10)**
.5 Write a testable question **(10)**
.6 Generate a valid hypothesis **(10)**
.7 Discriminate between a testable question and a hypothesis **(10)**
.8 Compare and contrast a list of hypotheses to determine if they are testable
.9 Formulate a single or multiple hypotheses on any given experiment/investigation **(10)**
.11 Use the independent and dependent variable to determine the materials, tools and techniques needed for an investigation **(10)**
.12 Formulate a sequential plan for an investigation **(10)**
.13 Identify and apply appropriate safety practices for an investigation **(10)**

See benchmark 2 for data collection and analysis ELEs

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 - .5: testable question, independent variable, Science, Scientific Method
.6 - .9: dependent variable, hypothesis, experiment, investigation

B12.0 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.

.1 Design data tables/setup and show an organizational strategy **(10)**
.2 Gather data (qualitative/quantitative) using appropriate measurements and methods **(10)**
.3 Apply the metric system by appropriate use of units and conversion factors **(10)**
.4 Apply appropriate mathematical analysis **(10)**
.5 Demonstrate graphing design (placement of dependent and independent variables/scaling/units/keys/titles/labels/graph types) **(10)**
.6 Identify possible sources of error **(10)**
.7 Identify and interpret trends in data using graphical analysis **(10)**
.8 Distinguish between precision and accuracy in measurement

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 - .3: qualitative, quantitative, error analysis
.4 - .8: experimental error, precision, accuracy

B13.0 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 Identify techniques used to review evidence (summary, graphical organizers, models) **(10)**
.2 Identify relationship between data trends and scientific concepts **(10)**
.3 Determine appropriate communication techniques to communicate and defend results **(10)**
.4 Communicate interpretations and conclusions using scientific concepts, mathematical relationships and technology **(10)**
.5 Justify and defend conclusions based on evidence **(10)**
.6 Explain why conclusions based on evidence are open to revision upon further investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

evidence, conclusion

B14.0 Analyze observations and explain with scientific understanding to develop a plausible model (e.g., atom, expanding universe).

.1 Identify various types of models (physical, mental, graphical, and mathematical) that can be used to illustrate scientific concepts **(10)**
.2 Explain why models are used to express scientific concepts **(10)**
.3 Use models to investigate and represent scientific concepts **(10)**
.4 Generate a model based on evidence gathered in an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

model

Course Content for Biology (cont.)

B15.0 Identify strengths, weaknesses, and assess the validity of the experimental design of an investigation through analysis and evaluation.

.1 Identify and assess the characteristics of a valid investigation **(10)**
.2 Identify experimental error and communicate suggestions for modified or redesigned experiment **(10)**
.3 Compare and contrast the validity of various experiments designed to measure the same outcome **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***
valid, experimental design

B16.0 Explain how observations of nature form an essential base of knowledge among the Montana American Indians (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Explain how observations of nature form and essential base of knowledge **(10)**
.2 Describe how Montana American Indians use observation to develop cultural knowledge and practices through examples **(10)**

CONTENT STANDARD 2—Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems.

All benchmarks under Standard 2 are addressed in Chemistry Course Content (C)

Course Content for Biology (cont.)

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.

B31.0 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 1blocks (e.g., proteins, carbohydrates, nucleic acids, lipids.

.1 Demonstrate appropriate microscopic techniques and tell the functions of each part **(10)**
.2 Recognize that a variety of microscopes exist and tell their uses **(10)**
.3 Identify common features among all cells **(10)**
.4 Compare and contrast prokaryotes and eukaryotes **(10)**
.5 Compare and contrast the structure, function and relationship of key cellular components **(10)** and organelles
.6 Identify key differences and similarities between plant and animal cells **(10)**
.7 Explain how concentration of substances affects passive transport ("diffusion" and "osmosis") and active transport **(10)**
.8 Explain the role of key biologically important macromolecules **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 & .2: compound light microscope, micrometer, field of view, depth of field, electron, tem, sem, MRI
.3 & .4: cell membrane, ribosome, genetic material, prokaryote, eukaryote, nucleus
.5 - .6: cell wall, chloroplasts, vacuoles, mitochondria, endoplasmic reticulum, **ribosomes,** golgi bodies, nucleus
.7: diffusion, osmosis, dynamic equilibrium, passive transport, semi-permeable membranes, active transport
.8: organic molecule, proteins, carbohydrates, lipids, nucleic acids, enzyme

B32.0 Describe and explain the complex processes involved in energy use in cell maintenance, growth, repair and development.

.1 Explain and give examples of the importance of a constant internal environment **(10)**
. 2 Identify processes that maintain homeostasis **(10)**
.3 Classify, compare and contrast various organisms as a heterotroph or autotroph **(10)**
.4 Describe the role of ATP in the body **(10)**
.5 Identify the key components involved in the chemical reaction of cellular respiration **(10)**
.6 Describe the conversion of stored energy in organic molecules into usable cellular energy (ATP) **(10)**
.7 Compare and contrast aerobic and anaerobic respiration **(10)**
.8 Summarize the conversion of light energy to chemical energy by photosynthetic organisms **(10)**
.9 Explain the relationship between the reactants and products of photosynthesis and cellular respiration **(10)**
.11 Explain the purpose of the cell cycle **(10)**
.12 Describe the stages of mitosis in plants and animals **(10)**

B32.0 Describe and explain . . . . (cont.)

.13 Identify the major events that occur in meiosis **(10)**
.14 Differentiate between haploid and diploid chromosome numbers **(10)**
.15 Compare and contrast the process and purpose of mitosis and meiosis **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 - .2: homeostasis
.3: heterotroph, autotroph
.4 -.7: cellular respiration, ATP, ADP, aerobic, anaerobic, mitochondria, fermentation, glycolysis
.8: glucose, chloroplast, photosynthesis, light and dark reactions
.9: glucose, carbon dioxide, oxygen, water, ATP
.11 - .12:chromosome, interphase, mitosis, prophase, metaphase, anaphase, telophase, cytokinesis, cell plate
.13 - .15:meiosis I and II, gamete, diploid (2n), haploid (1n), homologous pairs, zygote

B33.0 Model the structure of DNA and protein synthesis, discuss the molecular basis of heredity, and explain how it contributes to the diversity of life.

.1 Explain the functions of DNA and RNA **(10)**
.2 Compare and contrast the structure of DNA and RNA **(10)**
.3 Identify complementary base pairs **(10)**
.4 Explain the purpose and process of DNA replication **(10)**
.5 Explain the purpose and process of transcription and translation **(10)**
.6 Explain the relationship between DNA and heredity (Central Dogma) **(10)**
.7 Summarize the law of segregation and the law of independent assortment **(10)**
.8 Summarize how the process of meiosis produces genetic recombination **(10)**
.9 Explain the difference between dominant and recessive alleles **(10)**
.11 Distinguish between genotype and phenotype **(10)**
.12 Use the law of probability and Punnett squares to predict genotypic and phenotypic ratios **(10)**
.13 Identify and explain the different ways in which alleles interact to determine the expression of traits **(10)**
.14 Distinguish between sex chromosomes and autostomes **(10)**
.15 Explain how sex linked inheritance influences some genetic traits **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 - .3: mRNA, tRNA, DNA, nucleotide, adenine, cytosine, guanine, thymine, uracil, helical structure, rrnam Watson & Crick
.4 - .5: replication, transcription, translation, ribosome, DNA, protein synthesis, gene, codon, anti-codons
.6 - .8: heredity, Law of Independent, Assortment, Law of Segregation, crossing over, Gregor Mendel

Course Content for Biology (cont.)

Essential Vocabulary: (cont.)

.9 - .12: Punnett square, monohybrid cross, dominant allele, recessive allele, homozygous, heterozygous, phenotype, genotype, dihybrid cross ratio

.13 - .15: complete dominance, incomplete dominance, codominance, autosome, sex chromosome, sex-linked inheritance, pedigree, polygenic inheritance

.16 - .18: mutation, virus, nondisjunction, cancer

B34.0 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.

.1 Differentiate between biotic and abiotic factors in ecosystems **(10)**
.2 Discuss how abiotic and biotic factors influence biomes **(10)**
.3 Explain biogeochemical cycles **(10)**
.4 Recognize that the sun is the ultimate source of energy in MOST ecosystems **(10)**
.5 Explain the difference between a food chain and food web. **(10)**
.6 Explain trophic levels and pyramids in terms of energy transfer, biomass and number of individuals **(10)**
.7 Identify and predict density dependent and density independent factors that impact a population **(10)**
.8 Describe predator-prey dynamics **(10)**
.9 Compare and contrast the symbiotic relationships that exist between species **(10)**
.11 Describe how communities progress through a series of changes (succession) **(10)**
.12 Recognize that evolution involves a change in allele frequencies in a population across successive generations **(10)**
.13 Model and explain how natural selection can change a population **(10)**
.14 Describe the major factors that influence speciation **(10)**
.15 Explain Darwin's theory of evolution by natural selection **(10)**
.16 Explain the multiple lines of supporting scientific evidence of biological evolution **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1 & .3: ecology, biotic, abiotic, ecosystem, biome, biogeochemical cycle, biodiversity

.4 - .6: food chain, food web, trophic level, energy pyramid, biomass pyramid, pyramid of numbers

.7 & .8: community, limiting factors, competition, population, niche, carrying capacity

.9 & .11: symbiosis, commensalism, parasitism, mutualism, primary succession, secondary succession, climax community

.12 .16: natural selection, biological evolution, speciation, vestigial structures, homologous structures, geological fossil record, biochemical (DNA, protein), gene pool, gene flow, phylogenetic trees

Course Content for Biology (cont.)

B35.0 Generate and apply biological classification schemes to infer and discuss the degree of divergence between ecosystems.

.1 List and explain the characteristics of the three domains **(10)**
.2 Compare and contrast the key characteristics of each kingdom **(10)**
.3 Explain how similarities and differences in the key characteristics of each kingdom indicate the degree of divergence between them **(10)**
.4 Explain the classification of living organisms from the kingdom to species level**(10)**
.5 Explain the history and the importance of binomial nomenclature **(10)**
.6 Generate and use a dichotomous key **(10)**
.7 Differentiate between vascular and nonvascular plants
.8 Explain the difference between anigosperms and gymnosperms
.9 Compare and contrast major animal phyla
.11 Compare and contrast body systems between major animal phyla

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

.1: domain, bacteria, archaea, eukarya, viruses
.2 & .3: kingdom, eubacteria, archaebacteria, protista, fungi, plantae, animalia, phylogenetic trees
.4: classification, taxonomy, species,
.5 & .6: binomial nomenclature, dichotomous key, Linnaeus
.7 & .8: gymnosperm, angiosperm , vascular tissue, xylem, phloem
.9 & .11: invertebrate, vertebrate, body system, types of symmetry

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.

All the benchmarks under this standard are addressed in the HS Earth Science Course Content

Course Content for Biology (cont.)

CONTENT STANDARD 5—Students, through the inquiry process, understand how scientific knowledge and technological developments impact communities, cultures and societies.

B51.0 Predict how key factors (e.g., technology, competitiveness, and world events) affect the development and acceptance of scientific thought.

.1 Identify an example of scientific thought that has been or is affected by key factors such as technology, competitiveness (industrial, political, religious, etc.), world events, etc **(10)**
.2 Analyze how the development and/or acceptance of this example was influenced by various factors **(10)**
.3 Justify the analysis using cited peer-reviewed sources **(10)**
.4 Predict and discuss how key factors could impact the development and acceptance of scientific thought **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Biology)***

peer-review

B52.0 Give examples of scientific innovation challenging commonly held perceptions.

.1 Identify and discuss examples of commonly held perceptions or ideas being challenged by science (i.e. heliocentrism, flat earth, spontaneous generation) **(10)**

B53.0 Evaluate the ongoing, collaborative scientific process by gathering and critiquing information.

.1 Identify and discuss the practices employed by scientists to collaborate, share, and critique scientific information **(10)**
.2 Summarize the peer review process scientists use to critique and publish scientific research **(10)**
.3 Compare and contrast the formal and informal methods by which scientists communicate with each other and the public **(10)**

B54.0 Analyze benefits, limitations, costs, consequences, and ethics involved in using scientific and technological innovations (e.g., biotechnology, environmental issues).

.1 Identify various scientific and technological innovations **(10)**
.2 Compare and contrast the benefits and limitations of the various innovations **(10)**
.3 Analyze the cost and consequences of the innovations **(10)**
.4 Examine the ethical issues involved with the innovations **(10)**

Course Content for Biology (cont.)

B55.0 Explain how the knowledge of science and technology applies to contemporary Montana American Indian communities (e.g., natural resources development, management and conservation) (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify current practices by Montana American Indian tribes that are influenced by knowledge of science and technology **(10)**
.2 Explain how tribal sovereignty affects the use of science and technology within Montana American Indian communities **(10)**

CONTENT STANDARD 6—Students understand historical developments in science and technology.

B61.0 Analyze and illustrate the historical impact of scientific and technological advances, including Montana American Indian examples (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify important historical events in science and technology **(10)**
.2 Analyze the positive and negative impacts of past, present, and future science and technological advances **(10)**

B62.0 Trace developments that demonstrate scientific knowledge is subject to change as new evidence becomes available.

.1 Identify examples of scientific knowledge that have changed over time **(10)**
.2 Discuss the developments that contributed to the progression of the scientific knowledge **(10)**
.3 Analyze the impact of each development on the scientific knowledge **(10)**
.4 Summarize the process of the advancement of scientific knowledge **(10)**

B63.0 Describe, explain, and analyze science as a human endeavor and an ongoing process.

.1 Discuss the purpose of science **(10)**
.2 Summarize the parameters that guide the process of science **(10)**
.3 Examine the role of human reasoning in the process of science **(10)**
.4 Analyze how human interpretation of evidence affects the process of science **(10)**
.5 Describe how science is an ongoing process **(10)**

Content and Performance Standards for High School Earth Science

(10) = areas covered in the 10th grade MontCas

Course Content Identification Numbers:

The first symbol represents the grade level, the second symbol is the number of the state standard being addressed, the third number is the state benchmark being addressed and the decimal number is for the course content that addresses that specific standard and benchmark.

Example: E 23.1: E= HS Earth Science , 2= standard 2, 3=benchmark 3, 1= the first course content skill under the benchmark

The Essential Vocabulary is based on OPI's recommended vocabulary though ACE has often expanded the list of terms. The vocabulary words in bold, are OPI suggested vocabulary and may well be used in MontCAS testing.

ACE Course Abilities for HS Earth Science to be applied to Content Standards:

Develop abilities in science.

A. Higher thinking (analyze, evaluate, classify, predict, decide, relate, interpret).
B. Communications (present, demonstrate).
C. Goal setting/attainment (brainstorm, envision, research, plan, organize).
D. The planning process (plan, draft, analyze, and revise when producing products).
E. Be able to use SI units appropriately.

Apply science knowledge and skills to a variety of purposes.

A. Use the scientific method to solve problems and conduct experiments.
B. Conduct research.
C. Use scientific equipment appropriately and safely.
D. Apply knowledge of the relationship between humans, the environment and the earth's resources to improve the environment.
E. Possess technical skills:
   - read/write/present i.e.: instructions, table, chart, reports (progress, research, lab), proposal, letters (complaint, request, response), manual, checklist, pamphlet, technical research, bid, technical analysis, summary
   - technology i.e.: word processing, spreadsheet, database, desktop publishing, Internet, search tools, current technology

HS Earth Science Course Content

CONTENT STANDARD 1. Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

E11.0 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 the data.

.1 Identify the various applications of scientific investigations (explore new phenomena, check on previous results, develop and test hypothesis, and compare hypotheses) **(10)**
.2 Identify testable questions **(10)**
.3 Identify, from a set of questions, which question can be analyzed using a given set of sample data **(10)**
.4 Distinguish the independent and dependent variables by examining a scientific experiment/investigation **(10)**
.5 Write a testable question **(10)**
.6 Generate a valid hypothesis **(10)**
.7 Discriminate between a testable question and a hypothesis **(10)**
.8 Compare and contrast a list of hypotheses to determine if they are testable
.9 Formulate a single or multiple hypotheses on any given experiment/investigation **(10)**
.11 Use the independent and dependent variable to determine the materials, tools and techniques needed for an investigation **(10)**
.12 Formulate a sequential plan for an investigation **(10)**
.13 Identify and apply appropriate safety practices for an investigation **(10)**

See benchmark 2 for data collection and analysis ELEs

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

.1 - .5: testable question, independent variable, Science, Scientific Method
.6 - .9: dependent variable, hypothesis, experiment, investigation

E12.0 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.

.1 Design data tables/setup and show an organizational strategy **(10)**
.2 Gather data (qualitative/quantitative) using appropriate measurements and methods **(10)**
.3 Apply the metric system by appropriate use of units and conversion factors **(10)**
.4 Apply appropriate mathematical analysis **(10)**
.5 Demonstrate graphing design (placement of dependent and independent variables/scaling/units/keys/titles/labels/graph types) **(10)**
.6 Identify possible sources of error **(10)**
.7 Identify and interpret trends in data using graphical analysis **(10)**
.8 Distinguish between precision and accuracy in measurement

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
.1 - .3: qualitative, quantitative, error analysis
.4 - .8: experimental error, precision, accuracy

E13.0 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 Identify techniques used to review evidence (summary, graphical organizers, models) **(10)**
.2 Identify relationship between data trends and scientific concepts **(10)**
.3 Determine appropriate communication techniques to communicate and defend results **(10)**
.4 Communicate interpretations and conclusions using scientific concepts, mathematical relationships and technology **(10)**
.5 Justify and defend conclusions based on evidence **(10)**
.6 Explain why conclusions based on evidence are open to revision upon further investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
evidence, conclusion

E14.0 Analyze observations and explain with scientific understanding to develop a plausible model (e.g., atom, expanding universe).

.1 Identify various types of models (physical, mental, graphical, and mathematical) that can be used to illustrate scientific concepts **(10)**
.2 Explain why models are used to express scientific concepts **(10)**
.3 Use models to investigate and represent scientific concepts **(10)**
.4 Generate a model based on evidence gathered in an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
model

E15.0 Identify strengths, weaknesses, and assess the validity of the experimental design of an investigation through analysis and evaluation.

.1 Identify and assess the characteristics of a valid investigation **(10)**
.2 Identify experimental error and communicate suggestions for modified or redesigned experiment **(10)**
.3 Compare and contrast the validity of various experiments designed to measure the same outcome **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
valid, experimental design

E16.0 Explain how observations of nature form an essential base of knowledge among the Montana American Indians.
(go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Explain how observations of nature form and essential base of knowledge **(10)**
.2 Describe how Montana American Indians use observation to develop cultural knowledge and practices through examples **(10)**

CONTENT STANDARD 2 - Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems.

All benchmarks under Standard 2 are addressed in Chemistry Course Content (C)

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.

All benchmarks under Standard 3 are addressed in the Biology Course Content (B)

HS Earth Science Course Content (cont.)

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.

E41.0 Understand the theory of plate tectonics and how it explains the interrelationship between earthquakes, volcanoes, and sea floor spreading.

.1 Describe the independent movement of Earth's crustal plates **(10)**
.2 Describe the observations and evidence that led to the formation of the theory of plate tectonics **(10)**
.3 Model the interaction of heat-driven convection and the movement of the plates **(10)**
.4 Identify the types of plate boundaries **(10)**
.5 Model ways plates interact at plate boundaries **(10)**
.6 Contrast the different types of plate boundaries and the products of these plate interactions **(10)**
.7 Identify the causes of earthquakes **(10)**
.8 Explain volcanic processes **(10)**
.9 Relate earthquakes and volcanic activity to plate boundaries and other geologic settings **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

.1 - .6: continental drift, plate tectonics, subduction, convergent, divergent, transform, lithosphere,
.7 - .9: asthenosphere, sea floor spreading, convection, magma, viscosity, lava, seismic waves, stress, strain, fault

E42.0 Identify and classify rocks and minerals based on physical and chemical properties and the utilization by humans (e.g., natural resources, building materials).

.1 Define mineral **(10)**
.2 Describe the physical and chemical properties and equipment used to identify minerals **(10)**
.3 Classify minerals using observable properties, tools, and reference materials **(10)**
.4 Describe environments and processes that lead to the formation of various minerals **(10)**
.5 Define rock **(10)**
.6 Summarize the rock cycle and its process **(10)**
.7 Describe the physical and chemical properties and equipment used to identify rocks **(10)**
.8 Classify rocks into rock types using observable properties, tools, and reference materials **(10)**
.9 Identify various mineral and rock resources, their value, their uses, and their importance to humans **(10)**
.11 Explain how various mineral and rock resources are obtained **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

.1 - .4: crystal
.5 - .8: deposition, erosion, weathering, igneous, sedimentary, metamorphic
.9 & .11: ore, vein, mining

HS Earth Science Course Content (cont.)

E43.0 Explain scientific theories about how fossils are used as evidence of changes over time.

.1 Explain the concept of scientific theory **(10)**
.2 Explain how various fossils show evidence of past life **(10)**
.3 Model the scale of geologic time **(10)**
.4 Interpret rock layers using principles of relative and absolute age dating **(10)**
.5 Give examples of major biologic, climactic, and geologic changes in Earth's history and provide supporting rock and fossil evidence of these changes **(10)**
.6 Relate major changes to the divisions of geologic time **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
index fossils, fossil record, extinct, geologic time

E44.0 Collect and analyze local and regional weather data to make inferences and predictions about weather patterns; explain factors influencing global weather patterns and climate; and describe the impact on earth of fluctuations in weather and climate (e.g., drought, surface and ground water, glacial instability).

.1 Identify measurable weather-related variables commonly used in forecasting **(10)**
.2 Identify the instruments and technology used to collect weather data **(10)**
.3 Collect weather data and observe weather conditions **(10)**
.4 Summarize how cloud formation and precipitation are affected by changes in atmospheric conditions **(10)**
.5 Discuss the role of energy transfer in the atmosphere and its effects on weather changes **(10)**
.6 Describe the impacts of fronts, air masses, and pressure systems on local and regional weather **(10)**
.7 Analyze the effect of local geographic factors on weather **(10)**
.8 Use data to infer and predict weather patterns **(10)**
.9 Identify the geographic factors that influence climate **(10)**
.11 Determine which geographic factors result in specific local and regional climate **(10)**
.12 Examine the importance of the structure and composition of the atmosphere as influencing factors on Earth's weather and climate **(10)**
.13 Describe how global wind patterns influence weather and climate **(10)**
.14 Explain the relationship between ocean currents, weather, and climate **(10)**
.15 Compare the conditions that generate various types of severe weather **(10)**
.16 Discuss the impacts of various types of severe weather **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

.1 - .3: temperature, relative humidity, barometric pressure, dew point, wind, precipitation
.4 - .8: air mass, wind , Jet Stream, front, pressure system, weather, convection, water cycle
.9 - .14: coriolis effect, wind belts, ocean currents, latitude, elevation, climate, heat transfer, El Nino/LaNina, ozone layer
.15 - .16: tornado, hurricane

E45.0 Explain the impact of terrestrial, solar, oceanic, and atmosphere conditions on global climatic patterns.

.1 Identify examples of natural phenomena (terrestrial, atmospheric, oceanic, and astronomical) that impact global climate patterns **(10)**

.2 Explain the short and long term-effects of these natural phenomena on global climate patterns **(10)**

.3 Examine the geologic, astronomical, and human factors that contribute to global climate change **(10)** Describe socioeconomic and environmental implications of climate change**(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

climate, climate zones, climate change

E46.0 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.

.1 Describe the Big Bang Theory **(10)**

.2 Summarize evidence supporting the Big Bang Theory **(10)**

.3 Summarize the evolution of stars from birth to death **(10)**

.4 Identify the importance of fusion in a star's evolutionary cycle **(10)**

.5 Explain the relationship between stars and planets in a solar system **(10)**

.6 Compare and contrast the characteristics of planets and stars **(10)**

.7 Explain current theories of the formation of a solar system **(10)**

.8 Explain how the formation and evolution of a solar system influences the composition and placement of objects within it **(10)**

.9 Define galaxy **(10)**

.11 Describe the shape of the Milky Way Galaxy and our place in it **(10)**

.12 Illustrate the hierarchy of stars, planets, solar systems, galaxies and galactic group in the universe **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***

.1 - .5: Big Bang Theory, nebula, nova, nuclear fusion

.6 - .8: planet, star, solar system, accretion

.9 - .12: galaxy

E47.0 Relate how evidence from advanced technology applied to scientific investigations (e.g., large telescopes and spaceborne observatories), has dramatically impacted our understanding of the origin, size, and evolution of the universe.

.1 Discuss how various types of technology are used to study space **(10)**

.2 Compare the advantages and disadvantages of various tools used to study space **(10)**

.3 Assess how our understanding of the universe changes as technology advances**(10)**

E48.0 Explain the uniqueness of the earth and its ongoing processes of development.
.1 Identify landforms
.2 Interpret standard and topographic maps
Essential Vocabulary: (***Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
topographic, landforms

CONTENT STANDARD 5—Students, through the inquiry process, understand how scientific knowledge and technological developments impact communities, cultures and societies.

E51.0 Predict how key factors (e.g., technology, competitiveness, and world events) affect the development and acceptance of scientific thought.
.1 Identify an example of scientific thought that has been or is affected by key factors such as technology, competitiveness (industrial, political, religious, etc.), world events, etc **(10)**
.2 Analyze how the development and/or acceptance of this example was influenced by various factors **(10)**
.3 Justify the analysis using cited peer-reviewed sources **(10)**
.4 Predict and discuss how key factors could impact the development and acceptance of scientific thought **(10)**
Essential Vocabulary: (***Bold Vocabulary found on OPI's SCIENCE Vocabulary for HS Earth Science)***
.1 peer-review

E52.0 Give examples of scientific innovation challenging commonly held perceptions.
.1 Identify and discuss examples of commonly held perceptions or ideas being challenged by science (i.e. heliocentrism, flat earth, spontaneous generation) **(10)**

E53.0 Evaluate the ongoing, collaborative scientific process by gathering and critiquing information
.1 Identify and discuss the practices employed by scientists to collaborate, share, and critique scientific information **(10)**
.2 Summarize the peer review process scientists use to critique and publish scientific research **(10)**
.3 Compare and contrast the formal and informal methods by which scientists communicate with each other and the public **(10)**

E54.0 Analyze benefits, limitations, costs, consequences, and ethics involved in using scientific and technological innovations (e.g., biotechnology, environmental issues).
.1 Identify various scientific and technological innovations **(10)**
.2 Compare and contrast the benefits and limitations of the various innovations **(10)**
.3 Analyze the cost and consequences of the innovations **(10)**
.4 Examine the ethical issues involved with the innovations **(10)**

E55.0 Explain how the knowledge of science and technology applies to contemporary Montana American Indian communities (e.g., natural resources development, management and conservation) (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify current practices by Montana American Indian tribes that are influenced by knowledge of science and technology **(10)**
.2 Explain how tribal sovereignty affects the use of science and technology within Montana American Indian communities **(10)**

CONTENT STANDARD 6—Students understand historical developments in science and technology.

E61.0 Analyze and illustrate the historical impact of scientific and technological advances, including Montana American Indian examples (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify important historical events in science and technology **(10)**
.2 Analyze the positive and negative impacts of past, present, and future science and technological advances **(10)**

E62.0 Trace developments that demonstrate scientific knowledge is subject to change as new evidence becomes available.

.1 Identify examples of scientific knowledge that have changed over time **(10)**
.2 Discuss the developments that contributed to the progression of the scientific knowledge **(10)**
.3 Analyze the impact of each development on the scientific knowledge **(10)**
.4 Summarize the process of the advancement of scientific knowledge **(10)**

E63.0 Describe, explain, and analyze science as a human endeavor and an ongoing process.

.1 Discuss the purpose of science **(10)**
.2 Summarize the parameters that guide the process of science **(10)**
.3 Examine the role of human reasoning in the process of science **(10)**
.4 Analyze how human interpretation of evidence affects the process of science **(10)**
.5 Describe how science is an ongoing process **(10)**

Content and Performance Standards for Chemistry

(10) = areas covered in the 10th grade MontCas

Course Content Identification Numbers:

The first symbol represents the grade level, the second symbol is the number of the state standard being addressed, the third number is the state benchmark being addressed and the decimal number is for the course content that addresses that specific standard and benchmark.

Example: C 23.1: C=Chemistry, 2= standard 2, 3=benchmark 3, 1= the first course content skill under the benchmark

The Essential Vocabulary is based on OPI's recommended vocabulary though ACE has often expanded the list of terms. The vocabulary words in bold, are OPI suggested vocabulary and may well be used in MontCAS testing.

ACE Course Abilities for Physics to be applied to Content Standards:

Develop abilities in science.

A. Higher thinking (analyze, evaluate, classify, predict, decide, relate, interpret).
B. Communications (present, demonstrate).
C. Goal setting/attainment (brainstorm, envision, research, plan, organize).
D. The planning process (plan, draft, analyze, and revise when producing products).
E. Be able to use SI units appropriately.

Apply science knowledge and skills to a variety of purposes.

A. Use the scientific method to solve problems and conduct experiments.
B. Conduct research.
C. Use scientific equipment appropriately and safely.
D. Apply knowledge of the relationship between humans, the environment and the earth's resources to improve the environment.
E. Possess technical skills:
   - read/write/present i.e.: instructions, table, chart, reports (progress, research, lab), proposal, letters (complaint, request, response), manual, checklist, pamphlet, technical research, bid, technical analysis, summary
   - technology i.e.: word processing, spreadsheet, database, desktop publishing, Internet, search tools, current technology

Course Content For Chemistry

CONTENT STANDARD 1. Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations.

C11.0 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 the data.

.1 Identify the various applications of scientific investigations (explore new phenomena, check on previous results and compare hypotheses) **(10)**
.2 Identify testable questions **(10)**
.3 Identify, from a set of questions, which question can be analyzed using a given set of sample data **(10)**
.4 Distinguish the independent and dependent variables by examining a scientific experiment/investigation **(10)**
.5 Write a testable question **(10)**
.6 Generate a valid hypothesis **(10)**
.7 Discriminate between a testable question and a hypothesis **(10)**
.8 Compare and contrast a list of hypotheses to determine if they are testable
.9 Formulate a single or multiple hypotheses on any given experiment/investigation **(10)**
.11 Use the independent and dependent variable to determine the materials, tools and techniques needed for an investigation **(10)**
.12 Formulate a sequential plan for an investigation **(10)**
.13 Identify and apply appropriate safety practices for an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

.1 - .5: testable question, independent variable, Science, Scientific Method
.6 - .9: dependent variable, hypothesis, experiment, investigation

C12.0 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.

.1 Design data tables/setup and show an organizational strategy **(10)**
.2 Gather data (qualitative/quantitative) using appropriate measurements and methods **(10)**
.3 Apply the metric system by appropriate use of units and conversion factors **(10)**
.4 Apply appropriate mathematical analysis **(10)**

Course Content For Chemistry (cont.)

C12.0 Select and use appropriate tools . . . . (cont.)

.5 Demonstrate graphing design (placement of dependent and independent variables/scaling/units/keys/titles/labels/graph types) **(10)**

.6 Identify possible sources of error **(10)**

.7 Identify and interpret trends in data using graphical analysis **(10)**

.8 Distinguish between precision and accuracy in measurement

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

.1 - .3: qualitative, quantitative, error analysis

.4 - .8: experimental error, precision, accuracy

C13.0 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 Identify techniques used to review evidence (summary, graphical organizers, models) **(10)**

.2 Identify relationship between data trends and scientific concepts **(10)**

.3 Determine appropriate communication techniques to communicate and defend results **(10)**

.4 Communicate interpretations and conclusions using scientific concepts, mathematical relationships and technology **(10)**

.5 Justify and defend conclusions based on evidence **(10)**

.6 Explain why conclusions based on evidence are open to revision upon further investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

evidence, conclusion

C14.0 Analyze observations and explain with scientific understanding to develop a plausible model (e.g., atom, expanding universe).

.1 Identify various types of models (physical, mental, graphical, and mathematical) that can be used to illustrate scientific concepts **(10)**

.2 Explain why models are used to express scientific concepts **(10)**

.3 Use models to investigate and represent scientific concepts **(10)**

.4 Generate a model based on evidence gathered in an investigation **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

model

Course Content For Chemistry (cont.)

C15.0 Identify strengths, weaknesses, and assess the validity of the experimental design of an investigation through analysis and evaluation.

.1 Identify and assess the characteristics of a valid investigation **(10)**
.2 Identify experimental error and communicate suggestions for modified or redesigned experiment **(10)**
.3 Compare and contrast the validity of various experiments designed to measure the same outcome **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***
valid, experimental design

C16.0 Explain how observations of nature form an essential base of knowledge among the Montana American Indians (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Explain how observations of nature form and essential base of knowledge **(10)**
.2 Describe how Montana American Indians use observation to develop cultural knowledge and practices through examples **(10)**

CONTENT STANDARD 2—Students, through the inquiry process, demonstrate knowledge of properties, forms, changes and interactions of physical and chemical systems.

C21.0 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.

.1 Compare and contrast subatomic particles in relation to their relative masses, charges and location **(10)**
.2 Compare and contrast the number of subatomic particles in different elements and their isotopes **(10)**
.3 Recognize there is an electrical force of attraction/repulsion **(10)**
.4 Recognize the forces that keep the nucleus intact
.5 Explain radioactive decay and provide examples **(10)**
.6 Explain nuclear fission and fusion and provide examples

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***
.1 & .2: electron, proton, neutron, element, isotope, atomic mass, atomic number, quarks, leptons
.3 & .4: electrical force, strong **nuclear force**, gluons
.5 - .6: weak nuclear force, alpha particles, beta particles, gamma particles

Course Content For Chemistry (cont.)

C22.0 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.

.1 Recognize the Periodic Table is organized based on a series of repeating patterns **(10)**
.2 Utilize the periodic Table to determine the number of valence electrons of an element**(10)**
.3 Utilize the Periodic Table to predict, from neutral atoms, the formation of ions with the number of electrons gained or lost **(10)**
.4 Recognize that chemical properties of an element change with the number of valence electrons
.5 Compare and contrast ionic, covalent and hydrogen bonds **(10)**
.6 Describe the significance of electrons in interactions between atoms and why they sometimes form bonds
.7 Explain how the chemical bonding of a molecule affects its macroscopic (physical) properties
.8 Explain how the molecular geometry of a molecule (e.g. water) affects polarity and cohesive/adhesive properties **(10)**
.9 Describe the physical properties of each state of matter: solid, liquid, gas and plasma **(10)**
.11 Describe, using the kinetic molecular theory, the behavior of particles in each state of matter: solid, liquid, and gas
.12 Use a phase change diagram to describe changes energy and state
.13 Explain how electrons are shared in single, double, triple bonds
.14 Explain how the variety of carbon-carbon bonds leads to the diversity of biomolecules

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

.1 - .4: valence electrons, ions, groups, periods, cation, anion, polyatomic ion
.5 - .7: chemical bond, hydrogen bond, metallic bond, covalent bond, ionic bond
.8: polarity, cohesion, adhesion, molecular geometry
.9-.12: melting, freezing, sublimation, deposition, condensation, vaporization (boiling and evaporation), extensive properties, intensive properties
.13 - .14: single double, triple bonds, carbon-carbon bonds, biomolecules

Course Content For Chemistry (cont.)

C23.0 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.

.1 Provide evidence that a chemical change has occurred**(10)**
.2 Illustrate a chemical reaction using chemical formulas **(10)**
.3 Describe properties of chemical reaction classes (combustion, decomposition, synthesis, single-replacement, and double-replacement, etc.)
.4 Describe the energy changes in exothermic and endothermic reactions.
.5 Describe factors that affect the rate of reactions **(10)**
.6 Give examples of chemical reactions important to industry and living organisms **(10)**

Essential Vocabulary: : (*Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)*

.1 - .4: reactants, products, exothermic, endothermic, combustion, synthesis, single-replacement, double-replacement, oxidation/reduction, acid/base, activity series

.5: catalyst, activation, **energy**

C24.0 Identify, measure, calculate, and analyze relationships associated with matter and energy transfer or transformations, and the associated conservation of mass.

.1 Describe the law of conservation of mass **(10)**
.2 Measure and/or calculate energy transfer for a sample set of data or experiment
.3 Analyze the relationship between energy transfer and physical properties of matter
.4 Explain the unique circumstances allowing mass to transform into energy, or energy into mass

Essential Vocabulary: (*Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)*

Law of Conservation of Mass

C25.0 Explain the interactions between motions and forces, including an understanding of the gravitational and electromagnetic forces (eliminated ELEs A-G).

.1 Describe the relationship between magnetism and electricity and the resulting electromagnetic force

Essential Vocabulary: (*Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)*

electromagnetic force

Course Content For Chemistry (cont.)

C26.0 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.

.1 Describe the differences between kinetic energy and potential energy **(10)**
.2 Explain the relationship between kinetic energy and potential energy in a system **(10)**
.3 Discuss the conservation of energy **(10)**
.4 Recognize heat as a form of energy transfer **(10)**
.5 Explain the relationship between temperature, heat and thermal energy **(10)**
.6 Define the kinetic molecular theory and its relationship to heat (thermal energy transfer).
.7 Relate how energy tends to change from concentrated to diffuse states.

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

.1 - .3: energy, potential energy, kinetic energy
.4 - .7: joules, calories, temperature, heat, Kelvin scale

C27.0 Describe how energy and matter interact, including (a) waves, (b) the electromagnetic spectrum, (c) quantization of energy, and (d) insulators and conductors.

.1 Identify and illustrate different types of waves **(10)**
.2 Compare and contrast the similarities and differences between longitudinal and transverse mechanical waves **(10)**
.3 Explain how waves interact with media.
.4 Compare the various electromagnetic waves (gamma rays, x-rays, ultraviolet, visible, light, infrared, microwave, and radio waves) in terms of energy and wavelength **(10)**
.5 Identify practical uses of various electromagnetic waves **(10)**
.6 Compare the visible light colors in terms of energy and wavelength
.7 Recognize that atoms and molecules can gain or lose energy only in particular discrete amounts.
.8 Recognize that every substance emits and absorbs certain wavelengths
.9 Explain how electromagnetic waves are superposed, bent, reflected, refracted, and absorbed.
.11 Describe the difference between an electrical conductor and an electrical insulator **(10)**
.12 Describe the difference between a heat conductor and a heat insulator **(10)**
.13 Explain how electricity is involved in the transfer of energy **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***

.1 - .3: amplitude, wavelength, frequency, period
.4 - .9: electromagnetic spectrum, photon, reflection, refraction, emission spectrum, absorption spectrum
.11 - .13: current, resistance, voltage, power, conductor, insulator

Course Content For Chemistry (cont.)

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.

All benchmarks under Standard 3 are addressed in Biology Course Content (B)

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.

All benchmarks under Standard 4 are addressed in the High School Earth Science Course Content (E)

CONTENT STANDARD 5—Students, through the inquiry process, understand how scientific knowledge and technological developments impact communities, cultures and societies.

C51.0 Predict how key factors (e.g., technology, competitiveness, and world events) affect the development and acceptance of scientific thought.

.1 Identify an example of scientific thought that has been or is affected by key factors such as technology, competitiveness (industrial, political, religious, etc.), world events, etc **(10)**
.2 Analyze how the development and/or acceptance of this example was influenced by various factors **(10)**
.3 Justify the analysis using cited peer-reviewed sources **(10)**
.4 Predict and discuss how key factors could impact the development and acceptance of scientific thought **(10)**

Essential Vocabulary: ***(Bold Vocabulary found on OPI's SCIENCE Vocabulary for Chemistry)***
peer-review

C52.0 Give examples of scientific innovation challenging commonly held perceptions.

.1 Identify and discuss examples of commonly held perceptions or ideas being challenged by science (i.e. heliocentrism, flat earth, spontaneous generation) **(10)**

C53.0 Evaluate the ongoing, collaborative scientific process by gathering and critiquing information.

.1 Identify and discuss the practices employed by scientists to collaborate, share, and critique scientific information **(10)**
.2 Summarize the peer review process scientists use to critique and publish scientific research **(10)**
.3 Compare and contrast the formal and informal methods by which scientists communicate with each other and the public **(10)**

Course Content For Chemistry (cont.)

C54.0 Analyze benefits, limitations, costs, consequences, and ethics involved in using scientific and technological innovations (e.g., biotechnology, environmental issues).

.1 Identify various scientific and technological innovations **(10)**
.2 Compare and contrast the benefits and limitations of the various innovations **(10)**
.3 Analyze the cost and consequences of the innovations **(10)**
.4 Examine the ethical issues involved with the innovations **(10)**

C55.0 Explain how the knowledge of science and technology applies to contemporary Montana American Indian communities (e.g., natural resources development, management and conservation) (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify common materials used by Montana American Indians prior to industrial manufacturing (i.e., rosehips source of ascorbic acid)
.2 Explain how tribal sovereignty affects the use of science and technology within Montana American Indian communities **(10)**

CONTENT STANDARD 6—Students understand historical developments in science and technology.

C61.0 Analyze and illustrate the historical impact of scientific and technological advances, including Montana American Indian examples (go to www.opi.mt.gov/IndianEd for Science Model Lessons).

.1 Identify important historical events in science and technology **(10)**
.2 Analyze the positive and negative impacts of past, present, and future science and technological advances **(10)**

C62.0 Trace developments that demonstrate scientific knowledge is subject to change as new evidence becomes available

.1 Identify examples of scientific knowledge that have changed over time **(10)**
.2 Discuss the developments that contributed to the progression of the scientific knowledge **(10)**
.3 Analyze the impact of each development on the scientific knowledge **(10)**
.4 Summarize the process of the advancement of scientific knowledge **(10)**

C63.0 Describe, explain, and analyze science as a human endeavor and an ongoing process

.1 Discuss the purpose of science **(10)**
.2 Summarize the parameters that guide the process of science **(10)**
.3 Examine the role of human reasoning in the process of science **(10)**
.4 Analyze how human interpretation of evidence affects the process of science **(10)**
.5 Describe how science is an ongoing process **(10)**