

Science Standards

(with performance indicators)



SCIENCE STANDARDS

I. Nature of Science: Scientific Ways of Learning and Thinking

A. Cognitive skills in science

1. Utilize skepticism, logic, and professional ethics in science.

- examples
- Read or listen to statements of arguments carefully and critically, evaluate what evidence deserves attention and what should be dismissed, and distinguish careful arguments from questionable ones.
 - Recognize indicators and symptoms of faulty or unreliable statements or arguments. These indicators include the following:
 - Premises of the argument are not made explicit.
 - Conclusions do not follow logically from the evidence.
 - Argument is based on analogy but the comparison is faulty.
 - Fact and opinion intermingle, opinions are presented as fact, or it is not clear which is which.
 - Celebrity is used as authority.
 - Vague attributions are used in place of specific references or citations.
 - Reports of experimental results fail to describe appropriate controls.
 - Faulty graphs distort appearance of results by omitting data, omitting part of the scale, using no scale at all, etc.
 - Average (mean) results are reported, but not the amount of variation around the mean.
 - Absolute and proportional quantities or percentages are mixed together without clarification.
 - Other incorrect, misleading, or shoddy practices are used, as described in more detail in *Science for All Americans*, a report from Project 2061, AAAS, 1990.
 - Base alternate explanations on data and follow accepted, logical rules.

- examples
- Demonstrate ability to review and evaluate articles from a variety of sources, including scientific journals, websites, and popular publications to identify examples of proper statements and arguments, as well as examples where good practices were not exhibited.

2. Use creativity and insight to recognize and describe patterns in natural phenomena.

- examples
- Categorize a given collection of objects and describe the criteria for categorization (e.g., by constructing a dichotomous key).
 - Determine a line of best fit for a given set of graphical data and predict by interpolation or extrapolation where additional data points are likely to occur.
 - Formulate explanatory models, mechanisms, or narratives that relate observed features to each other and that describe cause-effect or other relationships among natural phenomena.
 - Examine and analyze new situations or problems in light of previously understood principles.

3. Formulate appropriate questions to test understanding of natural phenomena.

- examples
- Determine what additional data needs to be collected to draw conclusions from a given series of observations.
 - Make recommendations at the conclusion of an experiment, to extend, adjust, or apply the research conducted.

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4. Rely on reproducible observations of empirical evidence when constructing, analyzing, and evaluating explanations of natural events and processes.

examples

- a. Know how to keep and have experience in keeping a journal or other record that accurately describes observations, that distinguishes actual observations from ideas, speculations, and opinions about what was observed, and that is understandable weeks or months later.
- b. Review and evaluate articles from a variety of scientific journals and pseudo scientific/non-scientific publications and determine if the information is based on empirical evidence.
- c. Distinguish between personal opinion and evidence gathered by observation and analysis.

B. Scientific inquiry

1. Design and conduct scientific investigations in which hypotheses are formulated and tested.

examples

- a. Develop hypotheses that lead to if/then predictions and know that hypotheses leading to accurate predictions are tentatively accepted, while hypotheses that lead to inaccurate predictions are rejected or discarded.
- b. Formulate and clarify the method(s) of investigation, anticipating difficulties or needs for special equipment, time schedules, expenses, safety precautions, etc.
- c. Identify appropriate controls and variables in the investigation.
- d. Collect, organize, display, and analyze data according to an orderly plan, using data tables, graphs, narrative descriptions or other methods as appropriate.
- e. Compare predictions from hypotheses to data, and revise or discard hypotheses as appropriate.

examples

- f. Present results and seek critiques from others.
- g. Predict the effect on a dependent variable when an independent variable is altered.

C. Collaborative and safe working practices

1. Collaborate on joint projects.

- a. Work in teams and share responsibilities, acknowledging, encouraging, and valuing contributions of all team members.

2. Understand and apply safe procedures in the laboratory and field, including chemical, electrical, and fire safety and safe handling of live or preserved organisms.

examples

- a. Use Materials Safety Data Sheet (MSDS) information and demonstrate safe laboratory practices.
- b. Apply MSDS information to evaluate and guide safe practices in temporary storage and handling of chemicals in the classroom.
- c. Apply safe handling procedures for live and preserved organisms.

3. Demonstrate skill in the safe use of a wide variety of apparatuses, equipment, techniques, and procedures.

- a. Troubleshoot equipment and experimental set-ups under supervision and identify unsafe conditions or practices.

D. Current scientific technology

1. Demonstrate literacy in computer use.

examples

- a. Use a variety of hardware platforms and software applications effectively, including word processing, data analysis and statistics packages, detectors and data-gathering probes, and other peripheral equipment.

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2. Use computer models, applications and simulations.

examples

- a. Use computer models, simulations, data bases, visualizations, spreadsheets, and other applications to describe, analyze, and synthesize data and explanatory descriptions of natural phenomena.

3. Demonstrate appropriate use of a wide variety of apparatuses, equipment, techniques, and procedures for collecting quantitative and qualitative data.

examples

- a. Select a device, from a given assortment of measuring devices, that is most appropriate for data collection and explain why that device was chosen.

E. Effective communication of scientific information

1. Use several modes of expression to describe or characterize natural patterns and phenomena. These modes of expression include narrative, numerical, graphical, pictorial, symbolic, and kinesthetic.

- a. Translate information presented in any of these modes into any other of these modes of expression to produce equivalent statements.

2. Use essential vocabulary of the discipline being studied.

- a. Define and use a basic set of technical terms correctly and in context for each discipline studied.

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II. Foundation Skills: Scientific Applications of Mathematics

A. Basic mathematics conventions

1. Understand the real number system and its properties.

- a. Calculate sums, differences, products, and quotients of real numbers.
- b. Determine rates from magnitudes (e.g., speed from time and distance) and magnitudes from rates (e.g., the expected number of births if the birth rate and population size are known; estimate age of an artifact from carbon-14 data).
- c. Convert compound units (e.g., kilometers per hour into meters per second).
- d. Calculate circumference and area of rectangles, triangles, and circles, and the volumes of rectangular solids.

examples

2. Use exponents and scientific notation.

- a. Calculate sums, differences, quotients, and products using scientific notation.

3. Understand ratios, proportions, percentages, and decimal fractions, and translate from any form to any other.

- a. Calculate the relationships among common fractions, decimal fractions, and percentages.
- b. Calculate what percentage one number is of another and take a percentage of any number (e.g., 10 percent off, 60 percent gain).
- c. Find the reciprocal of any number.

examples

4. Use proportional reasoning to solve problems.

- a. Solve problems in which the result is expressed as a ratio or proportion of the starting conditions (e.g., predict genotype of parents if traits of offspring are known; starting from a known concentration, calculate the new

examples

concentration after serial dilutions; calculate doubling time of a population from growth rate).

5. Simplify algebraic expressions.

- a. Determine by numeric substitution the value of simple algebraic expressions [e.g., the expressions $aX+bY$, $a(A+B)$, and $(A-B)/(C+D)$].

6. Estimate results to evaluate whether a calculated result is reasonable.

- a. Estimate familiar lengths, weights, and time periods.
- b. Estimate distances and travel times from maps.
- c. Estimate actual sizes of objects based on scale drawings.
- d. Estimate probabilities of outcomes of familiar situations, either on the basis of history (e.g., the fact that a certain football team has won its opening game eight times in the last 10 years) or on the basis of the number of possible outcomes (e.g., there are six sides on a die).
- e. Trace the source of any large disparity between the estimate and the calculated answer.
- f. Figure out what the unit (e.g., seconds, square centimeters, dollars per tankful) of the answer will be from the inputs to the calculation.

examples

7. Use calculators, spreadsheets, computers, etc., in data analysis.

- a. Read and follow step-by-step instructions given in calculator manuals when learning new procedures.
- b. Make up and write out simple algorithms for solving problems that take several steps.
- c. Report the appropriate units with the numerical answer.

examples

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examples

- d. Judge whether an answer is reasonable by comparing it to an estimated answer.
- e. Round off the number appearing in the answer to an appropriate number of significant figures.
- f. Demonstrate competency in using scientific notation features on calculators.

B. Mathematics as a symbolic language

1. Carry out formal operations using standard algebraic symbols and formulae.

- a. Solve for unknown variables in an algebraic equation (e.g., solve for gas pressure, volume, or temperature, given an initial set of gas conditions).

2. Represent natural events, processes, and relationships with algebraic expressions and algorithms.

- a. Translate a narrative into an algebraic expression (e.g., write an equation from a word problem).

C. Understand relationships among geometry, algebra, and trigonometry

1. Understand simple vectors, vector notations, and vector diagrams, and carry out simple calculations involving vectors.

examples

- a. Carry out simple mathematical operations such as those presented in pre-calculus courses (e.g., determining slopes of lines or rates of change).
- b. Convert a numerical vector quantity (e.g., magnitude and direction) into a graphical vector representation.
- c. Perform graphical vector addition and subtraction.

2. Understand that a curve drawn on a defined set of axes is fully equivalent to a set of algebraic equations.

examples

- a. Construct graphs from given equations.
- b. Predict the shape of a curve without graphing.
- c. Plot the values of a given algebraic equation for a reasonable set of numerical parameters.

3. Understand basic trigonometric principles, including definitions of terms such as sine, cosine, tangent, cotangent, and their relationship to triangles.

- a. Use sine, cosine, tangent, etc., to carry out numerical and algebraic calculations using these terms.

4. Understand basic geometric principles.

examples

- a. Use geometric principles to solve problems dealing with molecular angles, optics, and surface area to volume ratios.
- b. Compute angle values using various geometric principles including the sum of angles in a triangle, alternate interior angles, and similar triangles.

D. Scientific problem solving

1. Use dimensional analysis in problem solving.

examples

- a. Use dimensional analysis to facilitate setting up calculations and to judge whether a final solution is reasonable.
- b. Convert complex metric units using dimensional analysis (e.g., kilograms per cubic meter to grams per cubic centimeter).

E. Scientific application of probability and statistics

1. Understand descriptive statistics.

examples

- a. Given a set of data, compute the mean, median, mode, range, standard deviation, standard error, and percent error.

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examples

- b. Evaluate whether two or more data sets show significant differences by comparing means, standard deviations, and standard errors.
- c. Use appropriate statistical tests to evaluate hypotheses.

examples

- c. Make measurements using various devices and record data with the correct number of significant figures.
- d. Distinguish between accuracy (i.e., closeness to true value), and precision (i.e., reproducibility).

F. Scientific measurement

1. Select and use appropriate Standard International (SI) units and prefixes to express measurements for real-world problems.

examples

- a. Know common SI prefixes (pico to tera), their abbreviations, and their associated powers of 10.
- b. Use SI base units (e.g., kilograms, meters) and derived units (e.g., liters, joules, and grams per cubic centimeter).
- c. Understand the relationship and usage of SI and standard English units in daily measurements.

2. Use appropriate significant digits.

examples

- a. Know the rules for adding, subtracting, multiplying, and dividing measurements using the appropriate number of significant digits.
- b. Apply an understanding of significant digits and estimated digits to evaluate and guide selection of appropriate measuring devices.

3. Understand and use logarithmic notation (base 10).

examples

- a. Using log tables or calculators, determine the log of a number between 1 and 10, and determine the value of a number from its logarithm (base 10).
- b. Express the value of the log (base 10) of a number greater than 10 or less than 1, using scientific notation.
- c. Recognize, without the help of log tables or calculators, the log (base 10) of any power of 10.
- d. Add or subtract numbers expressed as logs accurately to determine values represented.
- e. Use logarithms for calculations involving numbers less than one or greater than 10, i.e., numbers expressed with exponents of ten in scientific notation.
- f. Calculate the pH of a given molar concentration of an acid or alkaline (basic) solution.

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III. Foundation Skills: Scientific Applications of Communication

A. Scientific writing

1. Use correct applications of writing practices in scientific communication.

- examples
- Construct word (narrative) descriptions of apparatuses, equipment, techniques and procedures, data, and other features of scientific investigations with sufficient clarity that a layman reader can comprehend and replicate the items or arrangements being described.
 - Write accurate and understandable lab reports and technical documents.
 - Prepare a summary or abstract of a technical article or report, extracting in brief form the pertinent information.
 - Use appropriate terminology and data expression to communicate information in a concise manner.
 - Give credit to original authors including online or electronic sources and never take credit for words that are not one's own.
 - Write a technical report including a bibliography and proper documentation of sources using a standard style.

B. Scientific reading

1. Read technical and scientific articles to gain understanding of interpretations, apparatuses, techniques or procedures, and data.

- examples
- Describe the contents of a technical or scientific article.
 - Explain the importance of a technical or scientific article.
 - Make reasonable conclusions or predictions from given scientific article data.

2. Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions.

- Follow a written procedure to set up and perform a lab activity.

3. Recognize scientific and technical vocabulary in the field of study and use this vocabulary to enhance clarity of communication.

- Identify and define key scientific terminology from technical and scientific documents.

4. List, use and give examples of specific strategies before, during, and after reading to improve comprehension.

- examples
- List strategies to use before reading, including: activate prior knowledge of the topic, gain a clear understanding of the goal or purpose of the reading, and analyze the way in which the material is structured.
 - List strategies to use during reading, including: focus attention on the text; anticipate and predict what information the text is likely to contain; monitor understanding by self-questioning and the use of strategies (e.g., mental imagery, paraphrasing, information in glossaries) to re-examine the text if comprehension fails; reread difficult passages or read ahead for additional clarification; seek outside help for clarification; frequently self-monitor and summarize the information that has been gained.
 - List strategies to use after reading, including: summarize the major points in the text, and use graphic organizers (e.g., concept maps, problem-solution diagrams, cycle diagrams) to organize terms and concepts from the text in a visual manner.

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C. Presentation of scientific/technical information

1. Prepare and present scientific/technical information in appropriate formats for various audiences.

examples

- a. Make presentations using posters, spoken words, printed graphics, electronic applications (e.g., MS PowerPoint), and other formats.
- b. Present data or explanations extemporaneously without word-by-word reading of a prepared text.
- c. Answer questions generated by an oral presentation appropriately.

D. Research skills/information literacy

1. Use search engines, databases, and other digital electronic tools effectively to locate information.

- a. Use electronic tools to locate relevant information.

2. Evaluate quality, accuracy, completeness, reliability, and currency of information from any source.

- a. Distinguish relevant and reliable sources from other search results.
- b. Develop referencing skills to find needed background information.

IV. Science, Technology, and Society

A. Interactions between innovations and science

1. Recognize how scientific discoveries are connected to technological innovations.

- a. Give examples of technological innovations that resulted from various scientific discoveries.

B. Social ethics

1. Understand how scientific research and technology have an impact on ethical and legal practices.

examples

- a. Describe how scientific research and technology have an impact on ethical and legal practices in society.
- b. Recognize that honest and complete reporting of data, and fair, logically valid interpretation of data are the hallmarks of good science. Students should consistently follow these practices.

2. Understand how commonly held ethical beliefs impact scientific research.

- a. Discuss positive and negative influences of commonly held ethical beliefs on scientific practice.

C. History of science

1. Understand the historical development of major theories in science.

- a. Describe and explain the significance of historical development of quantum theory, modern atomic theory, biological evolution, plate tectonics, etc.

2. Recognize the role of people in important contributions to scientific knowledge.

- a. Describe the contribution of selected individuals who have made major contributions to particular disciplines.

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V. Cross-Disciplinary Themes

A. Matter/states of matter

1. Know modern theories of atomic structure.

examples

- Describe the characteristics and typical locations of subatomic particles such as protons, neutrons, and electrons.
- Describe what happens when an atom becomes an ion.

2. Understand the typical states of matter (solid, liquid, gas) and phase changes among these.

examples

- Explain the differences in volume, shape, and strength of attractive forces for each state of matter.
- Predict changes in the behavior of a gas sample as pressure, volume or temperature is changed.
- Identify the conditions under which a compound will be solid, liquid, or gas from a given phase diagram of a compound.

B. Energy (thermodynamics, kinetic, potential, and energy transfers)

1. Understand the Laws of Thermodynamics.

- Express thermodynamic principles in mathematical or symbolic statements.
- List and give examples of each law of thermodynamics.

2. Know the processes of energy transfer.

examples

- Cite specific examples of such transfer processes in biological, chemical, physical, and geological systems.
- Compare and contrast kinetic and potential energy.

C. Change over time/equilibrium

1. Recognize patterns of change.

examples

- Describe examples of physical and biological systems that remain stable over time, as well as examples of systems that undergo change.
- Describe feedback mechanisms that lead to stability to a system (homeostasis) and provide examples of such mechanisms.
- Describe cyclic change in terms of frequency, amplitude (maximum and minimum values), duration, and controlling factors, and illustrate these descriptions with examples of real cycles.
- Know that things can change in detail but remain the same in general (e.g., players are substituted in and out of the game but the team continues, individual cells are replaced but the organism remains alive), and give discipline-specific examples.
- Know that in biological systems, present forms arise from the materials and forms of the past both at the individual level (growth/development) and at the population level (evolution/speciation), and in ways that can be explained. Describe examples that illustrate such events and processes.
- Use graphs, symbolic equations, and other techniques for depicting and analyzing patterns of change.

D. Classification

1. Understand that scientists categorize things according to similarities and differences.

- Correctly use nomenclature for classification.

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examples

- b. Describe the characteristics of the different domains, kingdoms, and major phyla within the animal and plant kingdoms.
- c. Understand the Periodic Table and the atomic characteristics on which it is based.
- d. Know the major categories of minerals and describe characteristics that distinguish one from another.
- e. Recognize various soil types and the various horizons in soil structure; describe characteristics that distinguish one from the other.
- f. Know the Linnaean system of classification, taxonomy of organisms, and alternative classification systems such as cladistics.
- g. Distinguish among elements, compounds, and mixtures.

E. Measurements and models

1. Use models to make predictions.

- a. Create a model of a system and use that model to predict the behavior of a larger system.

2. Use scale to relate models and structures.

- a. Create a model of a larger system, properly scaling the model.

3. Demonstrate familiarity with length scales from sub-atomic particles through macroscopic objects.

examples

- a. Compare the order of magnitude estimates for metric sizes of a variety of objects (e.g., atomic nucleus, atom, molecule, grain of sand, pinhead, fingernail, baseball, city, state, country, planet, star).

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VI. Biology

A. Structure and function of cells

1. **Know that although all cells share basic features, cells differentiate to carry out specialized functions.**

examples

- a. Describe criteria for recognizing different functional cell types and give examples of such types including nervous, epithelial, muscle and other cells.
- b. Name and describe basic cell types found in living organisms.
- c. Give examples of particular modifications of cells, and explain how these modifications are related to each type's function in an organism.
- d. Recognize and describe major features that distinguish plant, animal and fungal cells.

2. **Explain in your own words how cells can be categorized into two major types: prokaryotic and eukaryotic, and describe major features that distinguish one from the other.**

- a. Describe or recognize major features that distinguish prokaryotic from eukaryotic cells.

3. **Describe the structure and function of major subcellular organelles.**

examples

- a. Describe or recognize the appearance or structure of ribosomes, cytoplasmic membrane, chromosomes, cell wall, eukaryotic nucleus, nucleolus, lysosomes, vacuoles, cytoskeleton, centrioles, cilia, flagella, Golgi apparatus, chloroplasts, mitochondria, and endoplasmic reticulum, and describe important functions of each.

4. **Describe the major features of mitosis and relate this process to growth and asexual reproduction.**

- a. Draw, describe, and place in sequence the various stages of mitosis.
- b. Identify the stages of mitosis when presented on a microscope slide, computer animation, or drawing during a practical lab exam.
- c. Arrange pictures or word descriptions of the stages of mitosis into correct sequence and describe or explain any significant events occurring in each stage.

5. **Understand the process of cytokinesis in plant and animal cells and how this process is related to growth.**

- a. Describe the major features and events of cytokinesis with pictures or word descriptions.

6. **Know the structure of membranes and how this relates to permeability.**

- a. Describe and explain the processes of osmosis and diffusion, and explain how the structure of plasma membranes permits and influences these events.

B. Biochemistry

1. **Understand the major categories of biological molecules: lipids, carbohydrates, proteins, and nucleic acids.**

- a. Describe the role of each type of biological molecule within a living system.
- b. Identify a biological molecule based on its formula and structure.
- c. Describe the major role of each biological molecule in biological structure and metabolism.

2. **Describe the structure and function of enzymes.**

- a. Describe the environmental effects (e.g., pH, temperature) on enzyme activity

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and explain why these affect the enzymes.

examples

- b. Give specific examples of enzymes and why they are important in the human body.
- c. Describe the chemical structure of proteins, including amino acids, peptide bonds, and polypeptide formation.
- d. Describe the effects of enzymes on reaction rates, including effects on activation energy requirements.

3. Describe the major features and chemical events of photosynthesis.

examples

- a. Explain the importance of chlorophyll.
- b. Describe patterns of electron flow through light reaction events.
- c. Describe significant features of the Calvin cycle.

4. Describe the major features and chemical events of cellular respiration.

examples

- a. Describe what Adenosine Triphosphate (ATP) is and its importance as an energy carrier molecule.
- b. Describe major features of glycolysis, Krebs cycle, electron transport system, and chemiosmosis.

5. Know how organisms respond to presence or absence of oxygen, including mechanisms of fermentation.

examples

- a. Conduct lab experiments regarding fermentation, respiration, and photosynthesis.
- b. Describe the role of oxygen in respiration, and describe pathways of electron flow in the absence of oxygen.
- c. Explain the advantages and disadvantages between fermentation and aerobic respiration.

6. Understand coupled reaction processes and describe the role of ATP in energy coupling and transfer.

- a. Describe reactions that produce and consume ATP.

C. Evolution and populations

1. Know multiple categories of evidence for evolutionary change and how this evidence is used to infer evolutionary relationships among organisms.

examples

- a. Describe features of biogeography/plate tectonics, fossil record, metabolism, DNA/protein sequences, homology, embryology, artificial selection/agriculture, and antibiotic resistance that contribute to our understanding of evolutionary change.

2. Recognize variations in population sizes, including extinction, and describe mechanisms and conditions that produce these variations.

examples

- a. Describe mechanisms that produce variations in population sizes.
- b. Recognize, describe, and explain typical patterns of change in population size (e.g., the logistic growth curve).
- c. Describe particular examples of extinction and describe conditions that produced these extinctions (e.g., Permian extinction, Cretaceous dinosaur extinction, woolly mammoth, passenger pigeon).
- d. Know that populations of organisms have changed, and continue to change over time, showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today.
- e. Describe general features of the history of life on Earth, including generally accepted dates and sequence of the geologic time scale and characteristics of major groups of organisms present during these time periods.
- f. Describe mechanisms that produce change in populations from generation to generation (e.g., artificial selection, natural selection, genetic drift, mutation, recombination).

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- g. Describe and explain processes and major events in natural selection, genetic drift, mutation, etc., and distinguish these processes from each other.

D. Molecular genetics and heredity

1. Understand Mendel's laws of inheritance.

examples

- a. Describe the laws of Mendelian genetics.
- b. Predict outcomes of a variety of test crosses and be able to predict parental genotypes for offspring.
- c. Use the laws of inheritance to carry out numerical calculations analyzing and predicting genetic characteristics of parents and offspring.
- d. Read a "genetics problem" and identify the information needed to complete a Punnett square.
- e. Determine phenotypes and genotypes of offspring from a given set of data about parental phenotypes and/or genotypes, expressing these features in numerical terms for cases of monohybrid and dihybrid crosses and other typical cases.
- f. Determine phenotypes and genotypes of parents from a given set of data about offspring phenotypes and/or genotypes, expressing these features in numerical terms.

2. Know modifications to Mendel's laws.

examples

- a. Determine phenotypes and genotypes of offspring from a given data set about parental phenotypes and/or genotypes; express these features in numerical terms for cases of co-dominance, quantitative inheritance, sex-linked traits, and other typical cases.

3. Understand the molecular structures and the functions of nucleic acids.

examples

- a. Research a genetic disorder and describe the cause of the disorder.
- b. Describe in words or pictures the molecular structure of DNA, RNA, and proteins.
- c. Describe in words or pictures the molecular events of replication, transcription, translation, and mutation.
- d. Describe the events and processes of molecular genetics: DNA controls synthesis of several types of RNA; RNA molecules plus proteins cooperate to synthesize new proteins; and proteins control structure and metabolism of cells.
- e. Describe the processes of electrophoresis and polymerase chain reaction, and explain their function in identifying DNA, RNA, and proteins.

4. Understand simple principles of population genetics and describe characteristics of a Hardy-Weinberg population.

examples

- a. Calculate phenotypes and genotypes of offspring populations from a given set of data about phenotypes and/or genotypes present in a population, using the Hardy-Weinberg equations.
- b. Describe and explain features of a population that must be present in order for Hardy-Weinberg calculations to be accurate.

5. Describe the major features of meiosis and relate this process to Mendel's Laws of Inheritance.

examples

- a. Explain the events of meiosis and the significance of these events to maintain chromosomal numbers.
- b. Explain how the events of meiosis produce the genetic effects described by Mendel's Laws of Inheritance.

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examples

- c. Arrange pictures or word descriptions of the stages of meiosis into their correct sequence and describe or explain any significant events occurring in each stage.
- d. Compare and contrast mitosis and meiosis.

E. Classification and taxonomy

1. **Know ways in which living things can be classified based on each organism's internal and external structure, development, and relatedness of DNA sequences.**

examples

- a. Explain the relationship between DNA sequences and physical characteristics.
- b. Describe the characteristics of each taxon and explain the significance in separating organisms.
- c. Distinguish similarities and differences among a given set of pictures or drawings of vertebrates during their development.
- d. Describe species diversity and cladistics, including the types of evidence and procedures that can be used to construct diagrams (e.g., phylogenetic trees).
- e. Construct cladograms and/or phylogenetic trees from simple data sets for major groups of organisms.
- f. Determine the correct classification and taxonomy of organisms from narrative or pictorial descriptions.

F. Systems and homeostasis

1. **Know that organisms possess various structures and processes (feedback loops) that maintain steady internal conditions.**

examples

- a. Describe examples of organisms that possess various structures and processes (feedback loops) that maintain steady internal conditions.

examples

- b. Describe examples of homeostasis (e.g., temperature regulation, osmotic balance, glucose levels) and describe the major features of feedback loops that produce such homeostasis.

2. **Describe, compare, and contrast structures and processes that allow gas exchange, nutrient uptake and processing, waste excretion, nervous and hormonal regulation, and reproduction in plants, animals, and fungi; give examples of each.**

examples

- a. Describe common gas exchange systems in plants and animals including anatomical features and functions.
- b. Describe common nutrient acquisition systems in plants, animals, and fungi, including anatomical features and functions.
- c. Describe common waste excretion systems in plants and animals, including anatomical features and functions.
- d. Describe common nervous/hormonal control systems in plants and animals, including anatomical features and functions.
- e. Describe common reproductive systems in plants, animals, and fungi including anatomical features and functions.

G. Ecology

1. **Identify Earth's major biomes, giving their locations, typical climate conditions, and characteristic organisms present in each.**

examples

- a. Name and describe Earth's major biomes including tundra, boreal forest, temperate deciduous forest, grasslands, deserts, tropical rain forests, estuaries and other wetlands, and marine biomes, including their typical locations, the typical organisms found in each, and important physical factors (e.g., temperature, rainfall rates) that produce these distribution patterns.

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2. Know patterns of energy flow and material cycling in Earth's ecosystems.

examples

- a. Describe patterns of energy flow and nutrient cycling through ecosystems.
- b. Describe and explain a trophic pyramid, including descriptions of typical organisms to be found at each trophic level in an ecosystem.
- c. Describe patterns of energy flow and nutrient cycling through ecosystems including the role of microorganisms.

3. Understand typical forms of organismal behavior.

examples

- a. Describe and give examples of organismal behavior (e.g., fixed action patterns, releasers, fight-or-flight responses, territorial displays, circadian rhythms).

4. Know the process of succession.

examples

- a. Describe events and processes that occur during succession, including changes in organismal populations, species diversity, and life history patterns over the course of succession.

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VII. Chemistry

A. Matter and its properties

1. **Know that physical and chemical properties can be used to describe and classify matter.**

examples

- a. Distinguish between physical properties (e.g., density, melting point) and chemical properties (e.g., ability to react, combustibility). Know that chemical changes create new substances (e.g., rusting), while physical changes do not (e.g., boiling).
- b. Understand that, as an intrinsic property, density does not change as sample size is changed, and be able to perform density calculations.

2. **Recognize and classify pure substances (elements, compounds) and mixtures.**

examples

- a. Describe separation techniques for both mixtures and compounds.
- b. Distinguish between homogeneous and heterogeneous mixtures.
- c. Understand that, as an intrinsic property, density does not change as sample volume is changed, and be able to perform density calculations.

B. Atomic structure

1. **Summarize the development of atomic theory. Understand that models of the atom are used to help us understand the properties of elements and compounds.**

examples

- a. Describe the discoveries of Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of the atom); understand how each discovery contributed to modern atomic theory.
- b. Identify the masses, charges, and locations of the major components of the atom (protons, neutrons, and electrons); describe Rutherford's "gold foil" experiment that led to the

discovery of the atomic nucleus; describe Millikan's "oil drop" experiment that led to determining the charge on an electron.

examples

- c. Describe basic wave properties (calculate wavelength, frequency, or energy of light) and understand that electrons can be described by the physics of waves.
- d. Explain the importance of quantized electron energy and its relationship to atomic emission spectra.
- e. Understand the electron configuration in atoms (Aufbau principle, the Pauli exclusion principle, Hund's rule) and their connection with the periodic table.

C. Periodic table

1. **Know the organization of the periodic table.**

examples

- a. Identify periods and groups on the periodic table.
- b. Identify metals, metalloids, and non-metals on the periodic table.
- c. Distinguish between and describe patterns in electron configurations for representative elements, transition elements, inner-transition elements, and noble gases. Predict the common charges on the representative elements from the periodic table.

2. **Recognize the trends in physical and chemical properties as one moves across a period or vertically through a group.**

examples

- a. Define each and describe the periodic trend: atomic radii, ionic radii, ionization energy, electron affinity, and electronegativity.
- b. Use the periodic trends to compare the size and behavior of atoms and ions.

Note: The Performance Indicators are not prescriptive, but serve as examples of ways students demonstrate the performance expectation.

SCIENCE STANDARDS

D. Chemical bonding

1. **Characterize ionic bonds, metallic bonds, and covalent bonds. Describe the properties of metals and ionic and covalent compounds.**

examples

- a. Draw Lewis dot structures for simple molecules, including simple hydrocarbons.
- b. Use Valence Shell Electron Pair Repulsion (VSEPR) model to predict molecular shapes.
- c. Describe nonpolar and polar covalent bonds. Use a chart of electronegativities to determine bond polarity.
- d. Determine if a molecule is polar (contains a dipole moment).

E. Chemical reactions

1. **Classify chemical reactions by type. Describe the evidence that a chemical reaction has occurred.**

examples

- a. Write equations for chemical reactions using appropriate symbols and balance the equations by applying the Law of Conservation of Mass. Write net ionic equations.
- b. Predict the products of a reaction that fall within the five general types of chemical reactions (synthesis, decomposition, single replacement, double replacement, and combustion).
- c. Use an activity series to predict whether a single replacement reaction will occur.
- d. Use solubility rules to determine the precipitate formed in a double replacement precipitation reaction.

2. **Describe the properties of acids and bases, and identify the products of a neutralization reaction.**

- a. Define pH and describe acid and base solutions in terms of pH. Use hydrogen ion or hydroxide ion

concentrations to determine the pH of an acid or base solution.

examples

- b. Use both commercial and non-commercial indicators to identify acid, base, and neutral solutions in a lab experiment.
- c. Distinguish between the Arrhenius and Bronsted definitions of acids and bases. Identify conjugate acid-base pairs.
- d. Describe how a titration is performed and how this process can be used to determine the concentration of an unknown acid or base solution.
- e. Measure and compare the pH of various common acids and bases (e.g., household cleaners, vinegar, citrus juice).

3. **Understand oxidation-reduction reactions.**

examples

- a. Differentiate between oxidation and reduction, and between oxidizing agent and reducing agent.
- b. Understand the consequences of corrosion processes and define and describe the electroplating process.
- c. Determine the oxidation number of any atom in an element, ion, or compound.

4. **Understand chemical equilibrium.**

examples

- a. Identify the factors that cause a shift in equilibrium (e.g., temperature, concentration, volume, and pressure).
- b. Explain LeChatelier's principle and use this principle to predict changes in the equilibrium position of a reaction.

5. **Understand energy changes in chemical reactions.**

examples

- a. Distinguish between endothermic and exothermic reactions. Draw energy diagrams for endothermic and exothermic reactions.
- b. Describe the Law of Conservation of Energy.

SCIENCE STANDARDS

6. Understand chemical kinetics.

examples

- Describe collision theory and use this theory to explain effects of concentration, temperature, and nature of reactants on reaction rate.
- Define catalyst and describe how a catalyst affects a reaction rate.

F. Chemical nomenclature

1. Know formulas for ionic compounds.

examples

- Name and write formulas for binary and ternary ionic compounds, using Group A (representative) metals and Group B (transition) metals, including those containing common polyatomic ions, (e.g., nitrate, sulfate, carbonate, ammonium, phosphate, hydroxide).

2. Know formulas for molecular compounds.

- Name and write formulas for binary molecular compounds and acids.
- Categorize a compound as ionic or molecular.

G. The mole and stoichiometry

1. Understand the mole concept.

examples

- Use Avogadro's number and molar mass to convert to moles of a substance. Determine the percent composition of a compound. Calculate the empirical formula of a compound from mass or percent composition data.

2. Understand molar relationships in reactions, stoichiometric calculations, and percent yield.

examples

- Construct mole ratios for a reaction to calculate the reactant amounts needed or product amounts formed in terms of moles or mass.
- Calculate percent yield, theoretical yield, or actual yield for a reaction.

H. Thermochemistry

1. Understand the Law of Conservation of Energy and processes of heat transfer.

examples

- Distinguish among radiation, convection, and conduction as means of heat transfer.
- Describe processes of heat transfer.
- Perform calculations involving heat transfer, using specific heat and latent heat (phase changes).

2. Understand energy changes and chemical reactions.

examples

- Describe and give examples of renewable and non-renewable energy resources.
- Describe endothermic and exothermic reactions.
- Know that systems naturally tend to move in a direction that increases disorder or randomness (entropy).

I. Properties and behavior of gases, liquids, and solids

1. Understand the behavior of matter in its various states: solid, liquid, gas.

examples

- Describe how gas pressure is affected by volume, temperature, and the addition of gas.
- Describe the behavior of solids, liquids, and gases under changes in pressure.

2. Understand properties of solutions.

examples

- Describe factors affecting solubility, units of concentration, colligative properties, and colloids.
- Calculate the molarity and molality of solutions.
- Determine boiling point elevation and freezing point depression for a solution.

SCIENCE STANDARDS

3. Understand principles of ideal gas behavior and kinetic molecular theory.

examples

- Use kinetic molecular theory to explain how gas pressure is affected by volume, temperature, and the addition of gas.
- Distinguish between real and ideal gas behavior, and identify the criteria in the kinetic molecular theory that conflict with the properties of real gases.

4. Apply the concept of partial pressures in a mixture of gases.

- Use Dalton's Law to determine the partial pressure of a gas in a mixture of gases.

5. Know properties of liquids and solids.

examples

- Describe the properties of liquids (e.g., surface tension, capillary action).
- Describe the structure of solids (e.g., crystal lattice structure, unit cell, amorphous solids).

6. Understand the effect of vapor pressure on changes in state; explain heating curves and phase diagrams.

- Define boiling, freezing, sublimation, etc.
- Explain heating curves and phase diagrams.

7. Describe intermolecular forces.

examples

- Distinguish between dispersion forces, dipole interactions, and hydrogen bonding. Identify the most important intermolecular force acting on a substance.

J. Basic structure and function of biological molecules: proteins, carbohydrates, lipids, nucleic acids

1. Understand the major categories of biological molecules: proteins, carbohydrates, lipids, and nucleic acids.

- Recognize each type by its structural formula, and describe simple chemical tests or procedures to detect, identify, or characterize each type.

K. Nuclear chemistry

1. Understand radioactive decay.

examples

- Identify the types of radioactive decay particles that occur, compare their properties (e.g., mass, charge, composition, penetrating ability), and write equations representing the decay processes.
- Explain the concept of half-life for a radioisotope, and use this concept to determine the amount of a certain sample of radioisotope remaining after a period of time, given the length of the half-life.
- Determine the length of time that has passed, given the remaining amount of radioisotope, the original amount of radioisotope, and the length of the half-life.
- Explain how carbon-14 is used to date artifacts.
- Compare and contrast the nuclear processes of fission and fusion.

SCIENCE STANDARDS

VIII. Physics

A. Matter

1. Demonstrate familiarity with length scales from sub-atomic particles through macroscopic objects.

examples

- a. Compare order of magnitude estimates for metric sizes of a variety of objects (e.g., atomic nucleus, atom, molecule, grain of sand, pinhead, fingernail, baseball, city, state, country, planet, star).

2. Understand states of matter and their characteristics.

examples

- a. Describe the states of matter in terms of volume, shape, and cohesive strength.
- b. State the physical changes associated with a change in phase.

3. Understand the concepts of mass and inertia.

examples

- a. Describe the concept of mass as a measurement of inertia.
- b. Compare order of magnitude estimates for masses of a variety of objects (e.g., electron, grain of sand, pebble, baseball, person, car, planet, star).

4. Understand the concept of density.

examples

- a. Define density as ratio of mass to volume. Apply the definition to calculate mass, volume, or density, given two of the three quantities.
- b. Calculate density of a homogeneous material and use it to identify the material.

5. Understand the concepts of gravitational force and weight.

- a. Qualitatively and quantitatively describe Newton's Law of Gravitation and the factors that affect the gravitational force between two objects.

examples

- b. Describe weight as a force of attraction to a large body and make computations of weight (using $W = mg$).
- c. Give examples to differentiate between mass and weight.

B. Vectors

1. Understand how vectors are used to represent physical quantities.

examples

- a. State several examples of scalar quantities.
- b. State several examples of vector quantities.
- c. Convert a numerical vector quantity (magnitude and direction) into a graphical vector representation.

2. Demonstrate knowledge of vector mathematics using a graphical representation.

examples

- a. Resolve a vector quantity (magnitude and direction) into perpendicular components using paper, a ruler, and a protractor.
- b. Add and subtract various vectors using paper, a ruler, and a protractor.

3. Demonstrate knowledge of vector mathematics using a numerical representation.

examples

- a. Resolve a numerical vector quantity (magnitude and direction) into perpendicular components using trigonometric functions and a calculator.
- b. Add and subtract various vectors using trigonometric functions and a calculator.

C. Forces and Motion

1. Understand the fundamental concepts of kinematics.

- a. State the definitions for displacement, distance, velocity, speed, and acceleration.

SCIENCE STANDARDS

examples

- b. Solve problems involving displacement, distance, velocity, speed, and acceleration.
- c. Solve one-dimensional kinematics problems for the case of constant acceleration.
- d. Create and interpret graphs of one-dimensional motion (e.g., position vs. time, velocity vs. time).
- e. Describe two-dimensional trajectory motion qualitatively and quantitatively.
- f. Describe the concept of relative motion and define a frame of reference.

2. Understand forces and Newton's Laws.

examples

- a. State Newton's Laws of Motion and demonstrate understanding of their application through lab activities.
- b. Solve for an unknown quantity using Newton's Second Law and the concept of equilibrium.
- c. Distinguish qualitatively between static and kinetic friction, and describe their effects on the motion of objects.

3. Understand the concept of momentum.

examples

- a. Define and calculate momentum and impulse. Clearly indicate how momentum is a vector.
- b. State the conditions under which momentum is conserved.
- c. Describe the term "impulse" in terms of force, time, and momentum. Illustrate the principle of impulse by citing several examples.
- d. Solve problems using impulse and the conservation of momentum.

D. Mechanical Energy

1. Understand potential and kinetic energy.

- a. Calculate potential energy values for various types of potential energy (gravitational, elastic, and electrical).

examples

- b. Calculate kinetic energy values (translational and rotational).
- c. Using a diagram of a pendulum or another energy conserving system, identify potential and kinetic energy at various locations.

2. Understand conservation of energy.

examples

- a. Describe the conversion of potential energy into kinetic energy (and vice-versa) in closed systems for which only conservative forces are present.
- b. Describe the conversion of energy in systems in which dissipative forces are present.
- c. Describe the general conservation of energy.

3. Understand the relationship of work and mechanical energy.

examples

- a. Compute net work as the product of net force and displacement, as the change in kinetic energy, and as the negative change in potential energy.
- b. Describe the concept of power and calculate average power.
- c. Distinguish between energy and power qualitatively, and state the dimensional units for each.

E. Rotating systems

1. Understand rotational kinematics.

examples

- a. Describe the relationships between the concepts and equations used for translational motion and those used for rotational motion.
- b. Define qualitatively: angular displacement, angular velocity, and angular acceleration.
- c. Complete computations including angular displacement, angular velocity, angular acceleration, tangential acceleration, and centripetal (radial) acceleration.

SCIENCE STANDARDS

examples

- d. Use examples to illustrate differences between tangential acceleration and centripetal (radial) acceleration.
- e. Explain why a net force (called centripetal) is required in order for an object to move in a circular path.

2. Understand the concept of torque.

examples

- a. Describe the concept of torque and compute torque values for various situations.
- b. Describe the concept of moment of inertia and compute moment of inertia values for various objects.
- c. Perform calculations using Newton's Second Law of Motion as applied to rotation.

3. Apply the concept of static equilibrium.

examples

- a. Describe the two conditions for which an object is in static equilibrium.
- b. Construct an equation using the concept of static equilibrium and solve for an unknown quantity.

4. Understand angular momentum.

- a. Describe the concept of angular momentum.
- b. Describe changes in angular velocity when moment of inertia changes.

F. Fluids

1. Understand pressure in a fluid and its applications.

examples

- a. Define pressure and make basic pressure computations using $\text{pressure} = \text{force} / \text{area}$ and appropriate units.
- b. Describe qualitatively and quantitatively how the pressure in a fluid changes with depth and explain the physical basis for the relationship.
- c. Describe the cause of atmospheric pressure and its variations.

2. Understand Pascal's Principle.

examples

- a. Describe and calculate changes in fluid pressure when external pressure is applied, especially as observed in hydraulic systems.
- b. Show how Pascal's Principle applies to hydraulic systems and calculate forces on both sides of a hydraulic system.

3. Understand buoyancy.

examples

- a. Define buoyant force and state Archimedes' Principle.
- b. Draw all the forces acting on an object submerged in a fluid. Discuss the conditions for sinking and floating in terms of the forces in the diagram.

4. Understand Bernoulli's principle.

- a. Qualitatively describe the relationship between fluid speed and fluid pressure in a closed system.

G. Oscillations and waves

1. Understand basic oscillatory motion and simple harmonic motion.

- a. Identify examples of oscillatory motion.
- b. Recognize examples of simple harmonic motion.

2. Understand the difference between transverse and longitudinal waves.

- a. Describe the motion of the medium as compared to the wave motion for both transverse and longitudinal waves.

3. Understand wave terminology: wavelength, period, frequency, amplitude.

examples

- a. Perform computations using the formula $(\text{wave speed}) = (\text{wavelength}) * (\text{frequency})$.
- b. Describe wavelength, frequency, amplitude, and period, and identify each from various wave graphs.

SCIENCE STANDARDS

4. Understand the properties and behavior of sound waves.

- a. Describe the properties and behavior of sound including compressions, rarefactions, and travel through various media.
- b. Compare and contrast sound and electromagnetic waves in terms of wave speed, wave type, wavelength, frequency, and medium.
- c. Describe the apparent change in frequency of waves due to the motion of a source or a receiver (the Doppler Effect).

examples

H. Thermodynamics

1. Understand the gain and loss of heat energy in matter.

- a. Describe, qualitatively and quantitatively, the relationship between heat and change in temperature, including the effects of mass and specific heat.
- b. Identify and compute the energy involved in changes of state.
- c. Explain the relationships among evaporation, condensation, cooling, and warming.
- d. Describe the transfer of heat by conduction, convection, and radiation.

examples

2. Understand the basic laws of thermodynamics.

- a. State and describe the laws of thermodynamics.
- b. Describe qualitative applications of the laws of thermodynamics and relate each to the concept of conservation of energy.

examples

I. Electromagnetism

1. Discuss electric charge and electric force.

- a. Describe electrical repulsion and attraction.

- b. State Coulomb's Law and use it to compute electrical force.
- c. Describe the concept of an electric field.

2. Gain qualitative and quantitative understandings of voltage, current, and resistance.

- a. Describe the concept of electric potential.
- b. Describe the concept of electrical charge flow and what limits that flow.
- c. Describe the concept of electrical resistance to charge flow.

examples

3. Understand Ohm's Law.

- a. Solve for unknown quantities using Ohm's Law.
- b. Determine electrical resistance from graphs of voltage versus current.

4. Apply the concept of power to electricity.

- a. Define electrical power as the product of current and voltage; perform simple calculations of power consumption.

5. Discuss basic DC circuits that include voltage sources and combinations of resistors.

- a. Summarize the electrical characteristics (current, voltage, total resistance) of a circuit consisting of two or more resistors wired in series.
- b. Summarize the electrical characteristics (e.g., current, voltage) of a circuit consisting of two or more resistors wired in parallel.
- c. Compare the electrical characteristics (e.g., current, voltage) of a circuit consisting of two or more resistors wired in parallel with those of the same components wired in series.

examples

SCIENCE STANDARDS

6. Discuss basic DC circuits that include voltage sources and combinations of capacitors.

examples

- Describe what a capacitor is and how it works.
- Summarize the electrical characteristics (e.g., current, voltage) of a DC circuit consisting of a battery and a capacitor.
- Summarize the electrical characteristics (e.g., current, voltage) of a DC circuit consisting of a capacitor and a resistor wired in series.

7. Understand magnetic fields and their relationship to electricity.

examples

- Describe the force experienced by a moving electric charge in a magnetic field.
- Describe moving electrical charge as the source of magnetic fields.
- Describe Faraday's Law and Lenz's Law.
- Describe the source of magnetism in matter.
- State the law of magnetic poles.

8. Relate electricity and magnetism to everyday life.

examples

- Explain how an electric motor works. State which electromagnetic laws or principles govern the workings of a motor.
- Explain how an electric generator works. State which electromagnetic laws or principles govern the workings of a generator.
- Make quantitative predictions of whether or not a circuit breaker will "trip" when a variety of electrical appliances are in use.

J. Optics

1. Know the electromagnetic spectrum.

examples

- Discuss the regions of the electromagnetic spectrum, including radio waves, microwaves, infrared, visible, ultraviolet, x-rays, and gamma rays.
- Discuss visible light as part of the electromagnetic spectrum. Emphasize that light is an electromagnetic wave.
- Recognize that electromagnetic waves are transverse waves and travel at the speed of light through a vacuum.
- Compare and contrast transmission, reflection, and absorption of radiation.

2. Understand the wave/particle duality of light.

examples

- Describe the behavior of light and why scientists have chosen to model it as both a particle and a wave.
- Give a practical example that illustrates light acting as a wave. Give a practical example that illustrates light acting as a particle.

3. Understand concepts of geometric optics.

examples

- Predict the path of a reflected light ray by applying the law of reflection to both diffuse and specular reflection.
- Define index of refraction. Predict the path of a light ray through a transparent material by application of Snell's Law.
- Identify convex, concave, and plane mirrors.
- Identify convex and concave lenses.
- Discuss qualitatively the images formed by mirrors and single lenses.
- Discuss qualitatively the images formed by combinations of mirrors and lenses (e.g., telescopes, microscopes, cameras).

SCIENCE STANDARDS

IX. Earth and Space Sciences

A. Earth systems

1. Know the major features and characteristics of atmosphere, geosphere, hydrosphere, and biosphere.

examples

- Describe major components and interactions within the atmosphere: gas composition, temperatures at various levels, ozone formation, and breakdown.
- Describe characteristics that identify and distinguish the core, mantle, and crust, including their locations, compositions, interactions with each other, and changes through time.
- Describe major components and interactions within the hydrosphere (the global ocean and its components).
- Describe major components and interactions within the biosphere, including major biogeochemical cycles (e.g., carbon cycle, oxygen-water cycle, nitrogen cycle, sulfur cycle, flow and storage of energy).

2. Understand relationships and interactions among atmosphere, geosphere, hydrosphere, and biosphere.

examples

- Describe interactions between oceans and climate.
- Describe effects of catastrophic events (e.g., volcanoes, earthquakes) on Earth systems.
- Describe impacts of the oceans on the Earth system (e.g., how the Earth's geologic history and present structure would have differed if the ocean had never formed).
- Describe effects of biological activity on the atmosphere (e.g., CO₂ levels, O₂ levels).

- Describe major effects of solar activity on the earth's atmosphere, hydrosphere including climate, ocean circulation, ozone formation, etc.

3. Possess a scientific understanding of the history of Earth's systems.

examples

- Describe methods and techniques for absolute and relative dating of geologic events and deposits.
- Describe general features of the geological history of Earth, including generally-accepted dates and sequence of the geologic time scale, physical and chemical conditions prevailing on Earth at different times, and major extinction events among organisms during these time periods.
- Explain how different surface processes (e.g., volcanism, erosion, tectonic, cratering) affect the planetary surface.

4. Utilize the tools scientists use to study and understand the Earth's systems.

- Use remote sensing tools (e.g., maps, visualizations, satellites, GPS/GIS, seismographs, weather balloons, buoys) and the data they provide.

B. Sun, Earth, and moon system

1. Understand interactions among the sun, Earth, and moon.

- Describe solar system processes that produce phases of the moon, solar and lunar eclipses, seasons, and tides.

2. Possess a scientific understanding of the formation of the Earth and moon.

- Describe current scientific theories and evidence for the origin of Earth and its moon.

SCIENCE STANDARDS

C. Solar system

1. Describe the structure and motions of the solar system and its components.

- Identify and describe the major components of the solar system (e.g., star, planets, comets, dwarf planets, kuiper objects, asteroids).

2. Possess a scientific understanding of the formation of the solar system.

- Describe the formation of the sun and the evidence that supports our understanding of this process.
- Explain the differences between the formation of rocky and gaseous planets.

examples

D. Origin and structure of the universe

1. Understand scientific theories for the formation of the universe.

- Describe current scientific theories and evidence for the origin of the Universe (the Big Bang) and formation of galaxies (Red Shift observations).
- Describe the life cycle of stars using the Hertzsprung-Russell diagram.

examples

2. Know the current scientific descriptions of the components of the universe.

- Describe types of galaxies and the characteristics that distinguish them.
- Describe general features of quasars and pulsars and the characteristics that distinguish them.

examples

E. Plate tectonics

1. Describe the evidence that supports the current theory of plate tectonics.

- Describe general features of the Earth's interior.
- Describe the role of convection currents in plate motion.

examples

2. Identify the major tectonic plates.

- Locate and identify the major tectonic plates and plate boundaries on a map.

3. Describe the motions and interactions of tectonic plates.

- Describe the geologic features that result from convergent, divergent, and transform plate boundaries.

4. Describe the rock cycle and its products.

- Identify common rocks and rock-forming minerals.
- Classify and describe the formation of rocks (igneous, metamorphic, sedimentary).

examples

F. Energy transfer within and among systems

1. Matter and energy in the Earth system.

- Describe Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).

2. Give examples of effects of energy transfer within and among systems.

- Describe energy sources and energy transfer processes (e.g., convection, conduction, radiation) that produce thunderstorms, hurricanes, tornadoes, and other weather events.
- Provide examples of how the uneven heating of Earth influences global circulation patterns (e.g., currents, winds, weather).
- Describe the effects of ocean currents on weather patterns.
- Describe the effects of large impacts on geological structures and atmospheric conditions, and cite examples of evidence of large impacts in Earth's history.

examples

SCIENCE STANDARDS

X. Environmental Science

A. Earth systems

1. Recognize the Earth's systems.

- Describe the characteristics that identify and distinguish the geosphere, atmosphere, hydrosphere, and biosphere.

2. Know the major features of the geosphere and the factors that modify them.

- examples
- Describe the characteristics that identify and distinguish the core, mantle, crust, and tectonic plates, including their locations, compositions, interactions among them, and changes through time.
 - Describe processes of weathering, erosion, deposition, etc. that make up the rock cycle.
 - Describe factors such as earthquakes, volcanoes, and other natural disasters and their impact on the size and location of populations of organisms, and the habitats they occupy.

3. Know the major features of the atmosphere.

- examples
- Describe the physical and chemical characteristics that identify different regions of the atmosphere.
 - Describe the factors that influence weather and climate, including atmospheric circulation, Coriolis Effect, and atmosphere-ocean interactions.

4. Know the major features of the hydrosphere.

- Describe the composition and location of bodies of salt water and fresh water.
- Describe patterns of ocean circulation, including currents and upwellings.

5. Be familiar with Earth's major biomes.

- Name and describe Earth's major terrestrial and aquatic biomes, including their locations, the characteristic

organisms found in each, and important physical factors (e.g., temperature, rain fall) that produce these distribution patterns.

examples

- Describe the adaptations of organisms found in each biome.

6. Describe the Earth's major biogeochemical cycles.

- examples
- Describe the carbon, oxygen-water, sulfur, nitrogen, and phosphorus cycles, including the chemical forms of each element at each stage of the cycle, and the chemical patterns of winds and ocean currents and provide information about changes in these patterns during events such as El Niño/La Niña.

B. Energy

1. Understand energy transformations.

- examples
- Describe patterns of winds and ocean currents and provide information about changes in these patterns during events such as El Niño/La Niña.
 - Describe how energy flows through the Earth's ecosystems while materials cycle repeatedly within these systems (e.g., food chains and webs, trophic levels, niches, predator-prey interactions, succession).

2. Know the various sources of energy for humans and other biological systems.

- examples
- Describe the major sources of energy, including fossil fuels, geothermal sources, wind energy, solar energy, nuclear energy, and others.
 - Describe methods and practices of energy conservation.

C. Populations

1. Recognize variations in population sizes, including human population and extinction, and describe mechanisms and conditions that produce these variations.

SCIENCE STANDARDS

examples

- a. Describe and explain carrying capacity, cultural and economic influences, urbanization, distribution, loss of biodiversity, endangered plants and animals, and deforestation.
- b. Explain how demographic structure of a population, birth and death rates, doubling times, and demographic transitions affect or produce changes in population size and composition.
- c. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population.

D. Economics and politics

1. Name and describe major environmental policies and legislation.

examples

- a. Describe and explain the goals and provisions of the Clean Water Act, the Endangered Species Act, and other major environmental policies and legislation.

2. Understand the types, uses and regulations of the various natural resources.

- a. Name the major U.S. National Parks and Monuments, stating where each is located, and the important features of each that justify protection.

E. Human practices and their impacts

1. Describe the different uses for land (land management).

examples

- a. Describe features of landscape and geology that lead different locations to be used for different purposes (e.g., agriculture, mining, recreation, urban settlement).

2. Understand the use and consequences of pest management.

- a. Describe major types of pesticides and herbicides, and other methods of controlling pests (e.g., biocontrol, genetically-modified organisms).

3. Know the different methods used to increase food production.

- a. Describe the features that identify and distinguish intensive agriculture, sustainable agriculture, organic agriculture, and other food and fiber production methods, including genetically modified organisms and livestock practices.

4. Understand land and water usage and management practices.

- a. Describe forestry practices (e.g., tree plantations, fire management).
- b. Describe rangeland management practices (e.g., grazing practices, conversion to grasslands, federal regulation).
- c. Describe management of urban land development, transportation infrastructure, public lands, and land conservation options.
- d. Describe regulation and management of mining practices.
- e. Describe regulation and management of fishing practices.

5. Understand how human practices affect air, water, and soil quality.

- a. Describe the formation and effects of acid deposition, ozone depletion, green house effect, and global warming.
- b. Describe different methods of managing waste.
- c. Describe the essential components and features of recycling, reuse, remediation, renew, landfills, wastewater, and water recycling.